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ABSTRACT

Reported are the findings from the 1976-77 assessment of attitudes toward science conducted by the National Assessment of Educational Progress (NAEP). Data were collected from four groups: 9-year-olds, 13-year-olds, 17-year-olds, and young adults. This contains a one-page summation of the highlights of the results, an introductory chapter describing the methodology of the study, and five additional chapters. These are entitled: (1) Personal Experiences with Science; (2) Science and Society; (3) Awareness of the Methods, Assumptions and Values of Science; (4) A Comparison of Results on Attitudinal and Cognitive Science Items; and (5) Implications and Perspectives. A bibliography and numerous tables and exhibits are included. (PB)

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ATTITUDES TOWARD SCIENCE

A Summary of Results From the 1976–77 National Assessment of Science

Report No. 08-S-02

by the
National Assessment of Educational Progress

Education Commission of the States
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FOREWORD

When the U.S. Office of Education was chartered in 1867, one charge to its commissioners was to determine the nation's progress in education. The National Assessment of Educational Progress (NAEP) was initiated a century later to address, in a systematic way, that charge.

Each year since 1969, National Assessment has gathered information about levels of education achievement across the country and reported its findings to the nation. NAEP surveys the education attainments of 9-year-olds, 13-year-olds, 17-year-olds and young adults, ages 26–35, in 10 learning areas: art, career and occupational development, citizenship, literature, mathematics, music, reading, science, social studies and writing. Different learning areas are assessed every year, and all areas are periodically reassessed in order to measure possible changes in education achievement. National Assessment has interviewed and tested more than 720,000 young Americans since 1969.

Learning-area assessments evolve from a consensus process. Each assessment is the product of several years of work by a great many educators, scholars and lay persons from all over the nation. Initially, these people design objectives for each subject area, proposing general goals they feel Americans should be achieving in the course of their education. After careful reviews, these objectives are given to exercise (item) writers, whose task it is to create measurement tools appropriate to the objectives.

When the exercises have passed extensive reviews by subject-matter specialists, measurement experts and lay persons, they are administered to probability samples. The people who compose these samples are chosen in such a way that the results of their assessment can be generalized to an entire national population. That is, on the basis of the performance of about 2,500 9-year-olds on a given exercise, we can make generalizations about the probable performance of all 9-year-olds in the nation.

After assessment data have been collected, scored and analyzed, National Assessment publishes reports to disseminate the results as widely as possible. Not all exercises are released for publication. Because NAEP will readminister some of the same exercises in the future to determine whether the performance level of Americans has increased, remained stable or decreased, it is essential that they not be released in order to preserve the integrity of the study.

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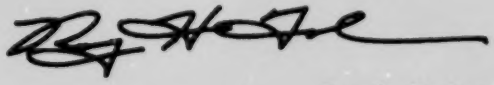
The administration of the science assessment was conducted by the Research Triangle Institute, Raleigh, North Carolina. Scoring was carried out by the Measurement Research Center, Iowa City, Iowa, and members of the National Assessment staff.

Rodger Bybee, Norris Harms, Roger T. Johnson, Jane Butler Kahle and Robert E. Yager generously contributed their time and expertise in writing interpretive papers for this report. Their efforts helped greatly in putting the data into perspective.

The actual preparation of this report was a collaborative effort of the National Assessment staff. Special thanks must go to the following people: Ingrid Larsson and James Damon for data processing support; Betty Homler for secretarial support; Ava Powell, Marci Reser and Paula Pitchford for production; and Rexford Brown for editorial support. Statistical analyses for this report were supervised by David Wright. The report was written by Barbara Ward.



Roy H. Forbes
Director

HIGHLIGHTS OF THE RESULTS

- Attitudes of 13- and 17-year-olds toward science were in many cases very much alike. Similar percentages at these ages expressed favorable attitudes toward science classes, were interested in pursuing science-related careers, used the scientific method of inquiry and were personally involved in solving science-related societal problems. More 17-year-olds than 13-year-olds supported research activities and were aware of the philosophy and methods of science; as would be expected, 17-year-olds had had more science-related experiences than 13-year-olds.

- More 9-year-olds expressed favorable attitudes toward science classes than 13- or 17-year-olds. They also appeared more willing than the older groups to try to help solve societal problems.

- About half the 13- and 17-year-olds, on the average, expressed favorable attitudes toward science classes and science-related careers.

- Willingness to participate in solving science-related societal problems was higher than actual participation for 9-, 13- and 17-year-olds.

- Males were more likely than females to have favorable attitudes toward science classes and science-related careers, to have had science-related experiences and to use the scientific method of inquiry. For teenagers, male and female support for research and awareness of the methods and philosophy of science were about the same. At the adult level, more males demonstrated support for research and awareness of the scientific method than females.

- At age 17, the following groups reported more favorable attitudes toward science classes and science-related careers than the nation as a whole: blacks, people living in the Southeast, people living in disadvantaged-urban communities and those living in big cities. Thirteen-year-olds in these groups exhibited more favorable attitudes toward science-related careers than the entire nation, while 13-year-olds living in advantaged-urban areas showed less favorable attitudes than the nation toward science classes and science-related careers.

- Groups that typically performed below the national level on cognitive science items were also below the national level in science-related experiences. The gap in experience levels appears to increase with age — groups of 17-year-olds who were below the national level for their age group were generally farther below it than their 13-year-old counterparts.

- Thirteen-year-olds, 17-year-olds and young adults were fairly supportive of research activities. On the average, 72% of the 13-year-olds, 78% of the

17-year-olds and 82% of the adults approved of spending money for various research endeavors. Levels of support were higher for applied than for basic research.

INTRODUCTION

Scientific and technological advances — from the expansion of cheap, rapid transportation, to new medical techniques, to the development of computer systems — have in large measure shaped the nature of American society. However, just as scientific advances have affected society, public attitudes toward science can influence the rate and nature of scientific discoveries.

The 1960s were marked by an upsurge in American scientific activity. Total national spending on research and development increased from $14.3 billion in 1961 to $26.0 billion in 1970 (National Science Board, 1976, p. 15). In contrast, support for scientific endeavors has not been consistent in the 1970s. Questions have been raised about potentially harmful applications of scientific study — and competition for scarce dollars has grown more intense.

What attitudes do Americans have toward science? Do they support scientific research? Do they view it as potentially harmful? Do they feel that science can be useful in solving societal problems? Do students enjoy learning about science? How many are interested in pursuing science-related careers? What experiences have they had with science-related activities?

As part of its 1976—77 assessment, the National Assessment of Educational Progress (NAEP) investigated attitudes toward science and science education. The majority of the survey questions were directed at 9-, 13- and 17-year-olds; however, some questions dealing with confidence in science to solve science-related societal problems, support for research, and awareness about scientific methods were also administered to young adults, ages 26—35.

Questions about science attitudes were categorized under three general topics: (1) personal experiences with science, (2) science and society and (3) awareness of the philosophy and methodology of science. Included under personal experiences with science were feelings about science classes, feelings about science-related careers, experiences with science-related activities and use of the scientific method of inquiry. Questions about science and society dealt with confidence in science, support for scientific research, feelings about research on controversial issues and personal involvement in helping solve science-related societal problems. Awareness of the philosophy and methodology of science involved understanding of the empirical nature of science, the tentativeness of scientific conclusions and the function of scientific theories.

Measuring Attitudes Toward Science

The objectives used to structure the 1976—77 science assessment were developed by groups of consultants representing science educators, scientists, science workers and lay citizens interested in education. Those objectives define what, in the consultants' opinions, young Americans should know and be able to do in the area of science. Attitudes toward science were included as part of the objectives.

In the area of attitudes, students generally achieve the objectives by holding attitudes "favorable" to science, as defined by the groups of consultants — for example, enjoying science classes, expressing willingness to help solve science-related societal problems, and so forth. "Favorable" is used as a descriptive term and is not meant to imply that everyone *must* hold such attitudes.

Some questions were of a survey nature and did not have answers indicating "achievement" of a certain objective. On these questions, National Assessment reports the percentages holding various opinions and monitors any changes in these percentages over time.

The attitudinal measures used in the science assessment rely on an individual's own reporting of his or her attitudes. Observation of people's activities might reveal behavior inconsistent with the attitudes professed under questioning. This limitation should be kept in mind when considering results presented in this report.

The Attitudinal Items

Questions investigating a particular type of attitude were often grouped together and presented to respondents as a series. While results for one question give information about a particular facet of people's attitudes, results from a number of questions about a topic can be aggregated to help us make more general statements about the attitudes people hold. In this report, percentages of favorable responses (responses said to meet an objective) to questions in a series were aggregated to provide an average percentage of favorable response to the concept being assessed by the series. This average can also be viewed as the percentage of questions to which the average person responded in a favorable way.

Averages are also computed across series of questions. These averages give an indication of feelings about more general topics — feelings about science classes, for instance — and allow for comparisons among different age and population groups.

Many attitudinal questions had two positive and two negative response options — for example, "strongly agree, agree" (the two positive) and "strongly disagree, disagree" (the two negative); the same is true for "always, often" and "seldom, never." In most cases, responses from the two positive or the two negative options have been combined for reporting data and for use in computing averages.

Thirteen- and 17-year-olds responded to identical sets of items, so item and average results for these two groups are directly comparable. Questions for adults were identical to those for the teenaged groups, but adults answered fewer items; thus, comparisons of average performance are not always possible. In most cases, questions for 9-year-olds differed slightly from those for the other age groups, and comparisons should be made only with caution.

Reporting the Data

The data reported here are estimates of the percentages of individuals who would answer a given question in a particular way. For example, when we say that "85% of the 13-year-olds agreed" with a statement, we mean that 85% is an estimate of the proportion of all the 13-year-olds in the country who would have answered in that manner if each 13-year-old in the country had been assessed. This estimate is based upon the weighted performance of our sample group. As in any sampling survey work, the percentage estimates are subject to sampling error because observations are made only on a sample, not on the entire population.

Reporting Group Performance

National Assessment provides data on the performance of 9-, 13- and 17-year-olds and young adults (ages 26—35); it also analyzes results for various groups within these national age populations. Because of sampling considerations, groups reported for adults are not always the same as those for the younger ages. In the following definitions of reporting groups, those reported for all age levels are listed first, followed by those used only for 9-, 13- and 17-year-old students, and then by those used only for adults.

Groups Defined for All Ages

Sex

Results are reported for males and females.

Race

Results are reported for whites and blacks.

Region

Results are reported for the following regions: Northeast, Southeast, Central and West. States included in each region are shown on the following map.

Level of Parental Education

Results are reported for three parental-education groups: (1) those whose parents did not complete high school, (2) those with at least one parent having graduated from high school and (3) those with at least one parent having had some post-high-school education.

Groups Defined for 9-, 13- and 17-Year-Olds Only

Size of Community

Big cities. Students in this group attend schools within the city limits of cities having a population over 200,000.

Fringes around big cities. Students in this group attend schools within metropolitan areas served by cities having a population greater than 200,000 but outside the city limits.

Medium cities. Students in this group attend schools in cities having a population between 25,000 and 200,000 not classified in the fringes-around-big-cities category.

Smaller places. Students in this group attend schools in communities having a population less than 25,000 not classified in the fringes-around-big-cities category.

Type of Community

These communities represent extreme community types. They are defined by an occupational profile of the area served by a school as well as the size of the community in which the school is located.

Advantaged-urban (high-metropolitan) communities. Students in this group attend schools in or around cities with a population greater than 200,000 where a high proportion of the residents are in professional or managerial positions.

Disadvantaged-urban (low-metropolitan) communities. Students in this group attend schools in or around cities with a population greater than 200,000 where a high proportion of the residents are on welfare or are not regularly employed.

Extreme-rural communities. Students in this group attend schools in areas with a population under 10,000 where most of the residents are farmers or farm workers.

Grade Level

For 9-year-olds, results for 3rd and 4th

grades are reported; for 13-year-olds, results for 7th and 8th grades; and for 17-year-olds, results for 10th, 11th and 12th grades.

Groups Defined for Adults Only

Community Size

Big cities/urban fringes. The big-city and urban-fringe groups defined for the younger ages are reported together for adults.

Medium cities/smaller places. The medium-city and smaller-places groups defined for the younger ages also are reported together for adults.

Own Education

Three levels of personal education are reported for adults: (1) those who have not graduated from high school (18%), (2) those who have graduated from high school (30%) and (3) those who have had some education beyond high school (52%).

Science Training

Results are reported for adults who had: (1) no formal training in science or technology beyond high school (60%) and (2) some formal training in science and technology beyond high school (40%).

Science-Related Job Experience

Results are given for adults who: (1) had job-related experiences in science or technology beyond high school (18%) and (2) did not have job-related experiences in science or technology beyond high school (79%). Approximately 3% of the respondents did not provide this information.

Other Reports on the Science Assessment

This report presents data on attitudes toward science and experiences with science. Other National Assessment reports on the science assessment describe changes in performance from the 1969–70 and 1972–73 science assessments and results on cognitive science items from the 1976–77 assessment (*Three National Assessments of Science*, 1978; *Science Achievement in the Schools*, 1978). Technical documentation of the assessment includes a set of released science exercises with national 1976–77 data (*The Third Assessment of Science, 1976–77*, 1978), a data appendix containing exercise-level results for groups (*Technical Appendix to the Third Assessment of Science, 1976–77*, 1978) and a summary volume displaying average performance on various sets of items and giving procedural documentation (*Three Assessments of Science, 1969–77: Technical Summary*, 1979).

CHAPTER 1

PERSONAL EXPERIENCES WITH SCIENCE

This chapter focuses upon young people's perceptions of their science classes, their attitudes toward science-related careers, their experience with science-related activities and their use of scientific methods of inquiry. Group results on specific questions or series of questions are discussed when they appear to differ appreciably from typical patterns or seem especially noteworthy. Group results are summarized at the end of each section.

Attitudes Toward Science Education

Do students enjoy their science classes? Do they find their teachers enthusiastic? Do they feel that the facts and methods they learn in science are useful? Do they pursue science-related activities outside of science classes?

As one indicator of their attitudes toward science classes, students were asked to name their most favorite school subject (Table 1). Nine-year-olds favored the subjects that they probably spend the most time with — mathematics and English/language arts — with science a distant third. Science dropped to fourth among most favorite subjects for teenagers, following mathematics, English/language arts and social studies.

TABLE 1. Percentages Naming Various Subjects in School as Their Most Favorite, Ages 9, 13 and 17

	Percent Naming Favorite Subject		
	Age 9	Age 13	Age 17
Science	6	11	12
Mathematics	48	30	18
English/language arts	24	15	16
Social studies	3	13	13
Other	19	31	41

Age 9 Results

Items for 9-year-olds touched upon feelings about science classes, science teachers and the usefulness of science. About 70% of the 9-year-olds, on the average, expressed favorable attitudes toward their science experiences in school.

Nearly all (95%) of the 9-year-olds said they had science in school; almost three-fifths said they would like to have more science than they presently do.

Nine-year-olds' feelings about science classes were assessed in the following question:

When you have science in school, how does it usually make *you* feel? Does science make *you* feel

		Yes	No	I Don't Know
A.	Happy?	62%	27%	11%
B.	Interested?	85	9	6
C.	Dumb?	5	89	6
D.	Excited?	50	38	11†
E.	Successful?	56	18	26

†Figures do not total 100% due to rounding.

Most agreed that science classes made them feel interested and denied that science classes made them feel dumb. Many were unsure

about whether science classes made them feel successful.

Nine-year-olds were also questioned about their perceptions of their science teachers. Reactions generally were favorable. For example, 73% said their teachers liked to have them ask questions, 70% stated that their teachers usually made science exciting, 68% felt that their teachers knew a lot about science and 66% said that their teachers let them present their own ideas. Most were unsure about whether their teachers really liked science — 60% replied "I don't know" when questioned. Slightly below half (45%) stated that their teachers ever said "I don't know" or admitted not knowing something.

About three-quarters of the 9-year-olds felt that the facts and ideas learned in science were useful to them when they were not in school, and most (94%) said science would help them a lot when they grew up. Black students were less likely than white students to think that the things learned in science were useful outside of school — only 57% of them responded affirmatively to that question.

Ages 13 and 17 Results

An average of about half the 13- and 17-year-olds gave favorable responses to questions about their science classes. On the following questions eliciting opinions about science classes, more 13-year-olds gave favorable responses than 17-year-olds.

While the majority of students were not afraid to ask questions in science classes, favorable responses to the other three questions in the exercise were given by less than half at either age.

More females than males at both ages found science classes boring. At age 13, responses of blacks and whites were fairly similar, but by age 17, more blacks than whites felt science classes were seldom or never boring (27% of blacks compared with

Please give your opinion on each of the following questions.

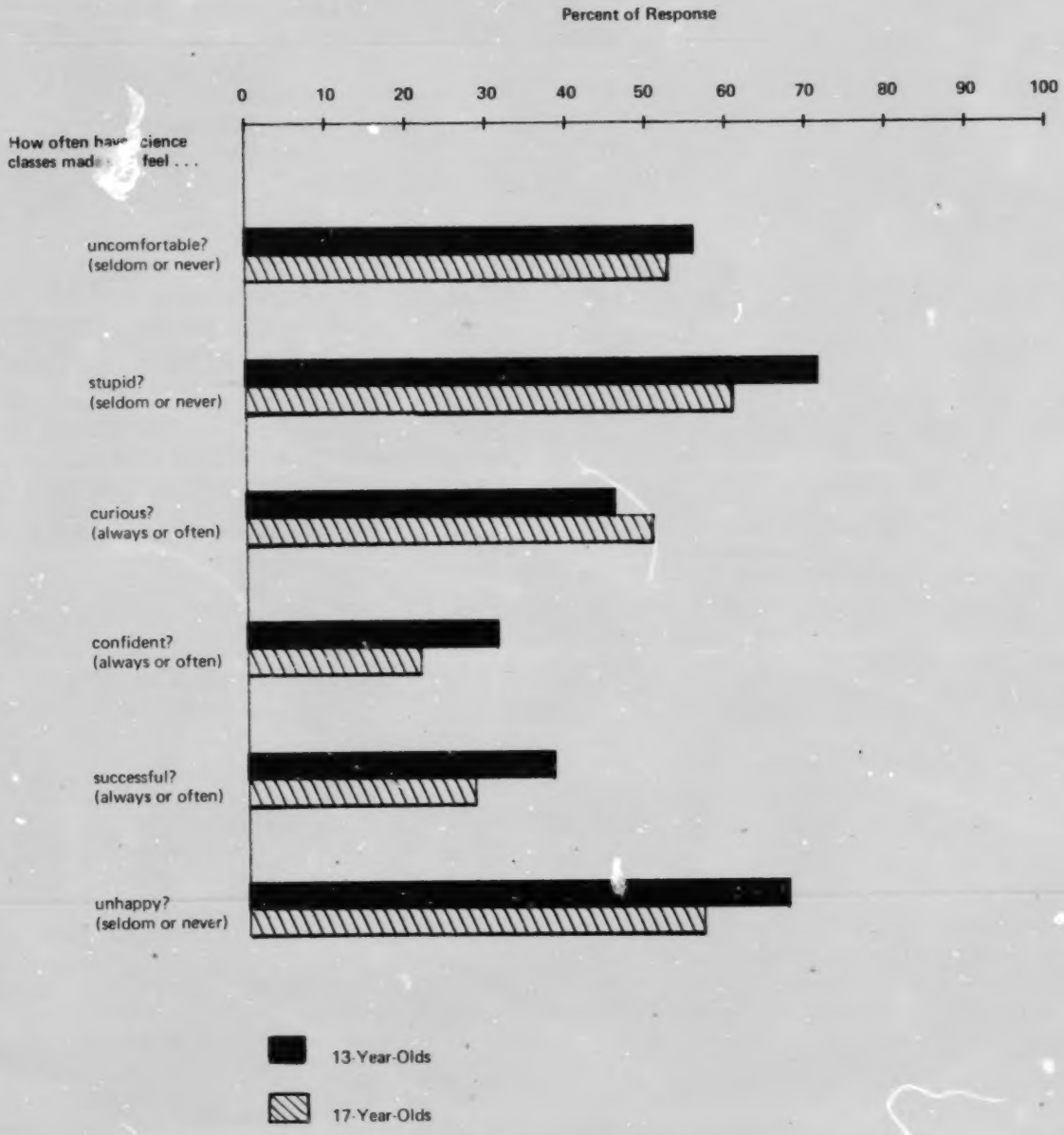
	Always or Often	Sometimes	Seldom or Never
A. How often are science classes boring?			
Age 13	21%	48%	31%†
Age 17	31	50	19†
B. How often are science classes fun?			
Age 13	40†	38	22
Age 17	26†	46	27**
C. How often do you like to go to science class?			
Age 13	44†	26	30
Age 17	37†	29	34
D. How often are you afraid to ask questions in science class?			
Age 13	17	21	62†
Age 17	18	22	59†**

†Designated a favorable response.
***Figures do not total 100% due to rounding.*

18% of whites), and considerably more blacks than whites said they always or often liked to go to science class (48% of blacks compared with 35% of whites).

Teenagers were asked to state the frequency with which science classes made them feel uncomfortable, stupid, curious, confident, successful or unhappy (Exhibit 1). They seemed more likely to reject negative feelings than to affirm strong, positive feelings. Percentages responding that they felt these emotions "sometimes" were often substantial. Around 45% at each age sometimes felt confident in science classes; around a third sometimes felt curious; nearly 30% sometimes

EXHIBIT 1. Percentages of 13- and 17-Year-Olds Expressing Various Emotions About Science Classes



felt uncomfortable; and close to one-fourth sometimes felt unhappy.

Several questions investigated attitudes toward the topics studied in science classes. Nearly half the 13- and 17-year-olds felt that the things they studied in class were always or often interesting. More students appeared to feel their science classes were too difficult rather than too easy. Forty-six percent at age 13 and 32% at age 17 saw their science classes as seldom or never too difficult; however, 60% and 63% at ages 13 and 17, respectively, felt that science classes were seldom or never too easy. Generally, students seem to regard science as comprised of facts that have to be memorized. Nearly half the 13-year-olds and 55% of the 17-year-olds felt science classes always or often consist of facts to be memorized, and an additional 33% at age 13 and 30% at age 17 felt science classes sometimes consist of such facts.

A series of six questions was designed to provide information on the instructional climate in science classrooms. Students were asked about their participation in determining topics to be studied, order of topics, speed at which students would work, etc. When results from all six were averaged, the percentages revealed a relatively low level of student participation in structuring class activities. An average of 22% at age 13 and 17% at age 17 said they had participated in the various planning activities.

Seventeen-year-olds appeared to exercise less choice in their classroom activities than 13-year-olds. Sixty-four percent and 75% at ages 13 and 17, respectively, said they seldom or never helped select the order in which they studied science topics; 29% of the 13-year-olds and 49% of the 17-year-olds said they seldom or never got to work at their own speed. Seventy-one percent of the 13-year-olds and 80% of the 17-year-olds said they seldom or never got to decide for themselves when they would be ready to hand in assignments and take tests. Forty-seven percent of the 13-year-olds and 39% of the 17-year-olds said they always or often followed the exact order of the textbook.

On the average, about three-fifths of each teenaged group perceived their science teachers favorably (Table 2).

TABLE 2. Percentages of 13- and 17-Year-Olds Agreeing With Various Statements About Their Science Teachers

Tell how much you agree or disagree with each of the following statements regarding your present or most recent science teacher. My present or most recent science teacher

		Percent Responding Strongly Agree or Agree	
		Age 13	Age 17
A.	Really likes science.	76	81
B.	Wants students to point out mistakes he or she makes.	63	59
C.	Makes science exciting.	58	48
D.	Is enthusiastic.	52	57

Many students stated that their science teachers really like science, but there could be some difficulty in transmitting that enthusiasm to students, since percentages perceiving their teachers as enthusiastic or making science exciting were markedly lower.

Students were also questioned about their perceptions of teachers' attitudes toward their students. Perceptions of 13- and 17-year-olds seemed very similar. Approximately two-thirds at each age believed their teachers often or always encouraged them to think for themselves. Forty-two percent of the 13-year-olds and 44% of the 17-year-olds felt their science teachers always or often encouraged them to state their opinions. Lower percentages — 19% at age 13 and 22% at age 17 — felt their teachers often or always took a personal interest in them. Twenty percent and 17% of the 13- and 17-year-olds, respectively,

said their teachers often or always admitted that they did not know something.

As shown in Exhibit 2, most teenagers agreed that science classes are useful. Percentages feeling that things learned in science would be useful to them in the future were higher than those feeling that those things were currently useful in everyday life.

How often do students participate in science-related activities when not required to do so for science classes? Students were given a list of eight activities and asked if they participated in the activity often, sometimes, seldom, or never. Table 3 displays national percentages of 13- and 17-year-olds saying they participated in various activities "often" or "sometimes."

TABLE 3. Percentages of 13- and 17-Year-Olds Participating in Various Science-Related Activities Outside of Science Classes

How often have you done each of the following activities when *not required* for science class?

	Percent Saying They Often or Sometimes Participate	
	Age 13	Age 17
Read science articles in magazines	47	48
Read science articles in newspapers	41	47
Watched science shows on TV	58	62
Gone to hear people give talks on science	8	8
Read books about science or scientists	45	29
Talked about science topics with your friends	41	37
Done science projects	68	49
Worked with science-related hobbies	45	37
Average percentage reporting participation	44	39

Close to three-fifths at each age stated that they often or sometimes watched science shows on television. About half had often or sometimes read science articles in magazines. Fewer than 10% at either age had voluntarily gone to hear talks on science. Thirteen-year-olds were considerably more likely than 17-year-olds to read books about science, do science projects and work with science-related hobbies.

Exhibit 3 displays average percentages of respondents participating voluntarily in science-related activities for several selected reporting groups. As one might expect, boys at both ages 13 and 17 were more likely than girls to participate in science activities outside school; the difference increased for the older students. Blacks in both age groups were more likely than whites to report that they participated in extracurricular science activities.

Summary of Group Results

Percentages responding in a favorable manner to questions about science classes were averaged for various reporting groups within each age population.

For 9-year-olds, about the same percentage in each group expressed favorable opinions about science classes. Any differences that did exist were quite small.

At age 13, variations in group results were again small. Males displayed slightly more favorable attitudes toward science classes than females. Somewhat surprisingly, 13-year-old students living in advantaged-urban areas displayed less favorable attitudes toward science classes than the nation as a whole.

Differences were, however, apparent for 17-year-olds. Those living in the Southeast, blacks, those living in disadvantaged-urban areas and in big cities showed, on the average, more favorable attitudes than the national group of 17-year-olds. Like 13-year-olds, 17-year-old males reported slightly more favorable attitudes than females. Those living

EXHIBIT 2. Percentages of 13- and 17-Year-Olds Agreeing With Statements About Science Classes

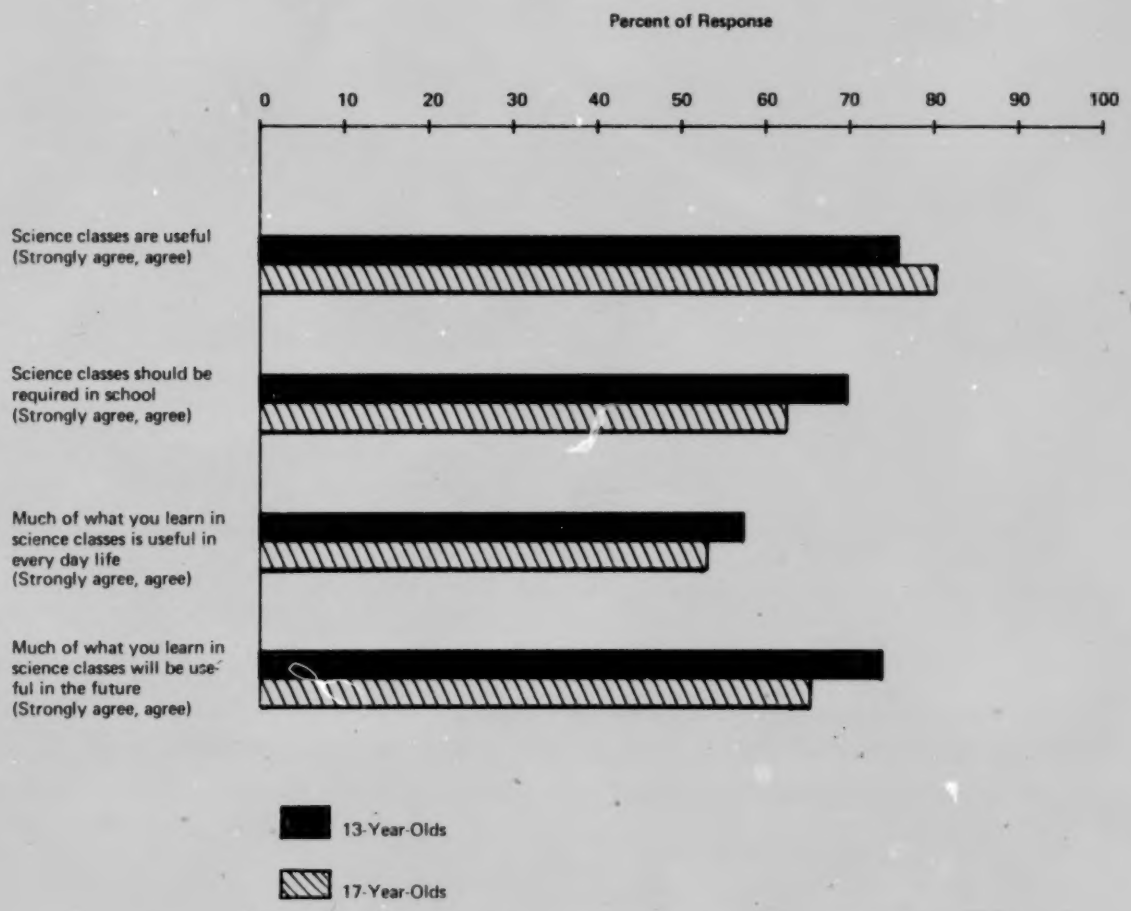
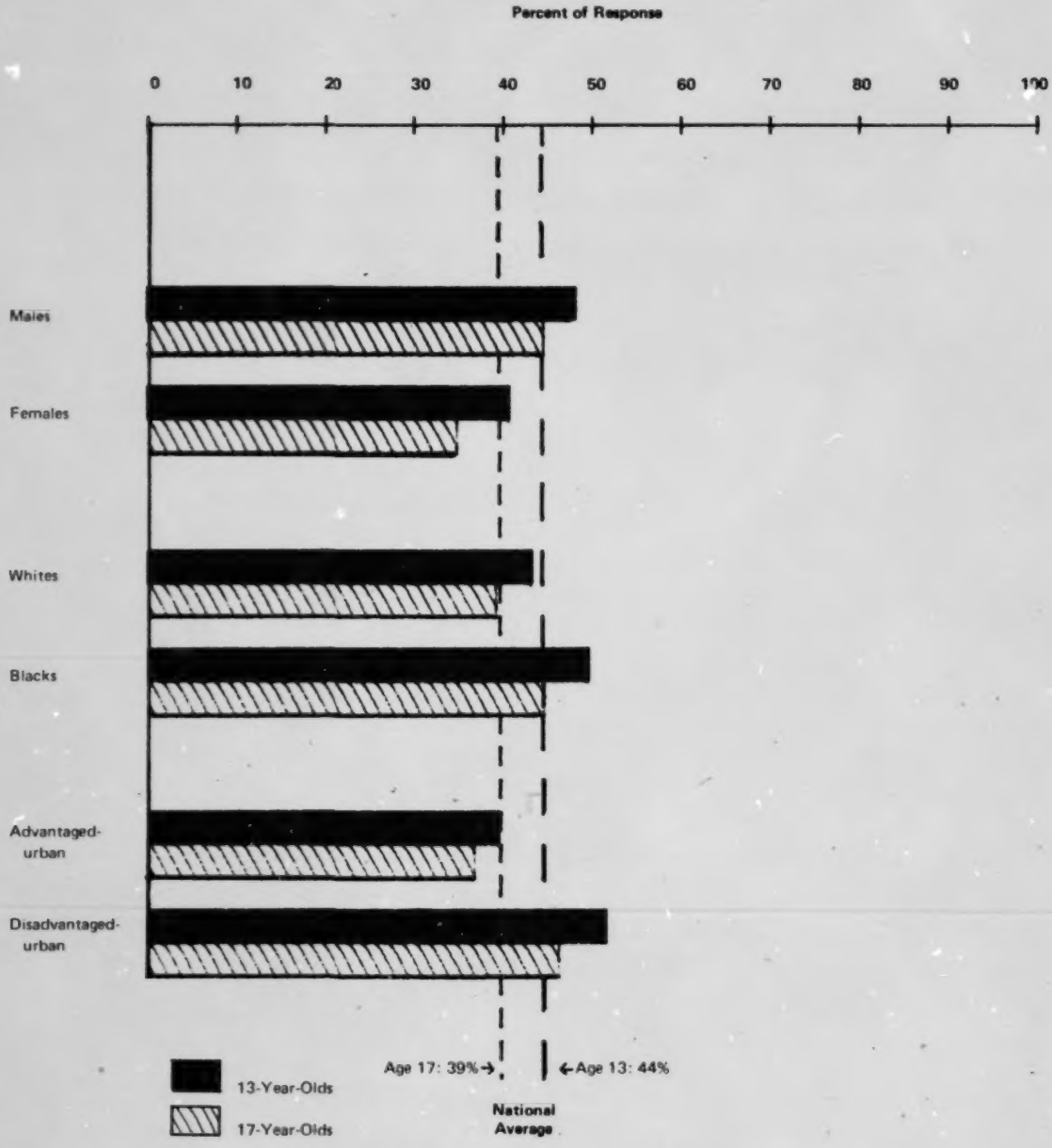


EXHIBIT 3. Average Percentages of Selected Groups Reporting Participation in Science-Related Activities Outside Science Classes, Ages 13 and 17



in extreme-rural areas held less favorable attitudes than the nation; attitudes of advantaged-urban 17-year-olds did not differ significantly from those of the nation as a whole.

Vocational and Educational Intentions

Age 9 Results

Nine-year-olds were asked what they thought being a scientist would be like. On the average, about two-thirds expressed favorable attitudes toward being a scientist. Sixty-four percent agreed that being a scientist would be fun, and 69% felt that it would make them important. Sixty-one percent said being a scientist would not be too much work for them, and 68% stated that the job would not be boring.

On these questions, 9-year-old boys were slightly more favorable to the idea of being a scientist than were girls. Blacks were somewhat less enthusiastic than whites. More of those whose parents had graduated from high school or had post-high-school education expressed favorable attitudes than those whose parents had not finished high school.

Ages 13 and 17 Results

About half the 13- and 17-year-olds (52% and 48%, respectively) appeared favorable to the idea of science as a career.

On the next page are responses to general indicators of interest in science careers. Seventeen-year-olds were equally as confident as 13-year-olds in their ability to do science-related jobs and equally interested in finding out about jobs, but otherwise their desire to work in a science-related field or observe scientists at work was somewhat lower than that of 13-year-olds.

Average percentages for groups on this series of questions differed considerably, as shown in Exhibit 4. Blacks and students living in disadvantaged-urban areas were more likely to express favorable attitudes on these questions than the nation as a whole; percentages for females, whites and 13-year-old advantaged-urban students were below the national averages.

Another series of questions investigated teenagers' interest in doing science-related tasks. An average of about half the 13- and 17-year-olds expressed interest in doing the six tasks listed. Interest in sharing ideas with others and in designing and building things was fairly high. Seventy-seven percent of the 13-year-olds and 81% of the 17-year-olds said that they would like to share ideas with others; 66% of the 13-year-olds and 63% of the 17-year-olds were interested in designing and building things. However, only 46% of the 13-year-olds and 43% of the 17-year-olds wanted to work in a laboratory; 46% at age 13 and 41% at age 17 would like to write reports about their findings; 34% of the 13-year-olds and 44% of the 17-year-olds expressed interest in making field studies; and 32% and 29% at ages 13 and 17, respectively, were interested in reading science articles. It may be that reading science articles did not sound interesting in the context of the other questions, since between 40 and 50% of the teenagers reported that they do read science articles in magazines or newspapers (Table 2).

Both groups of teenagers were asked about their feelings toward working in a science-related field. Results were not very different from those for the series of questions discussed previously. On seven questions, an average of 51% of the 13-year-olds and 44% of the 17-year-olds expressed favorable opinions about working in science-related fields.

About half the 13- and 17-year-olds, on the average, expressed favorable views about the education and training required to work in a scientific field. Table 4 shows responses to specific questions.

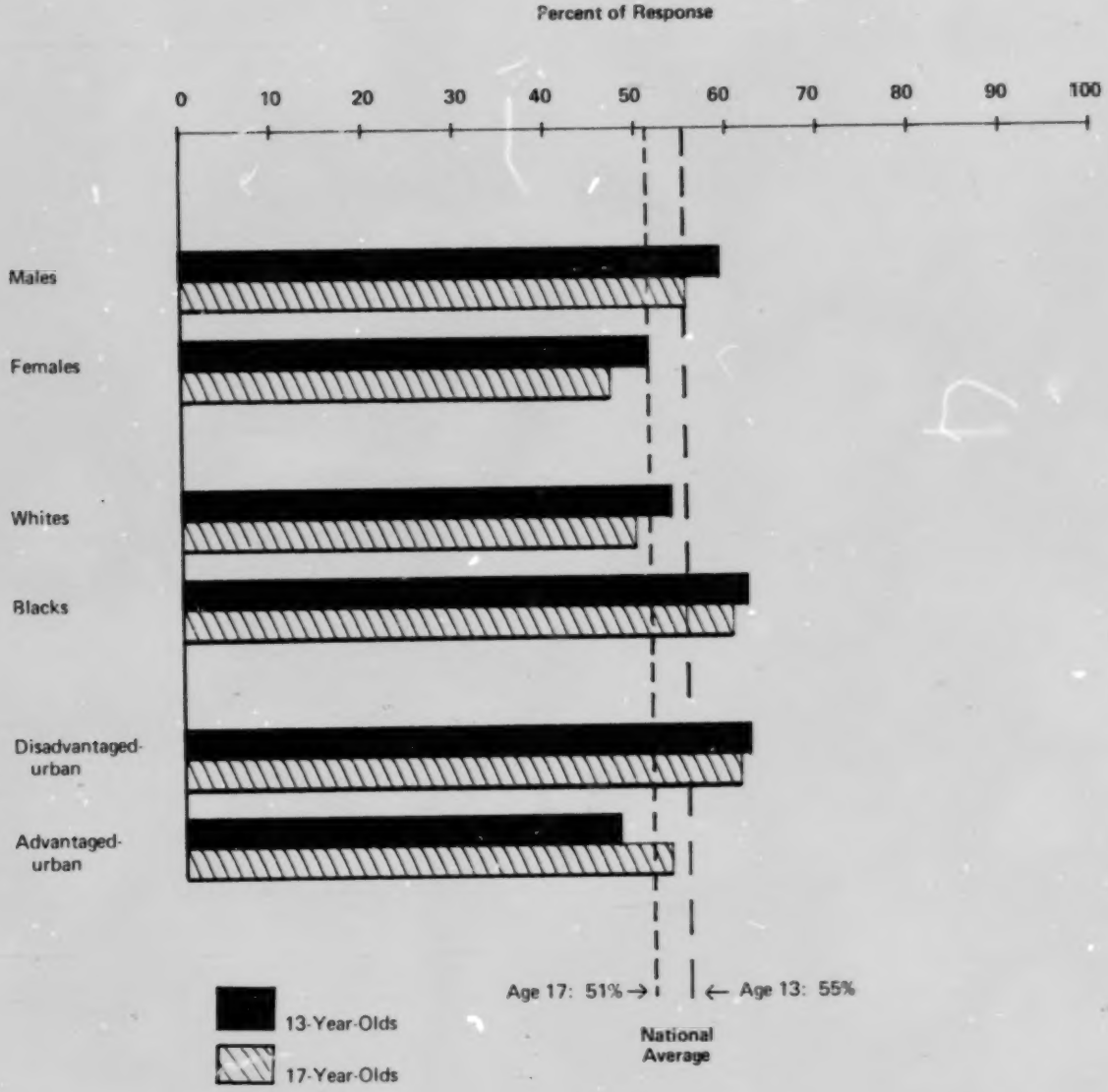
Percentages for 13- and 17-year-olds were

	Definitely or Probably Yes†	Not Sure	Probably or Definitely Not
A. Do you plan to stop taking science courses after you have taken as many as your school requires?			
Age 13	33%	32%	35%
Age 17	47	16	38**
B. Would you like to work at some job that lets you use what you know about science?			
Age 13	48	24	27**
Age 17	39	25	35**
C. Do you want to work with scientists in an effort to solve problems?			
Age 13	43	27	30
Age 17	32	29	39
D. Would you like to visit a scientist at work?			
Age 13	81	10	9
Age 17	71	13	16
E. Do you think that there are science-related jobs that you can learn to do?			
Age 13	76	17	7
Age 17	77	14	9
F. Would you like to know more about jobs in a science or engineering field?			
Age 13	48	25	27
Age 17	51	18	31
Average expressing favorable attitudes over six questions.			
Age 13	55		
Age 17	51		

†Denotes favorable response.

***Figures do not total 100% due to rounding.*

EXHIBIT 4. Average Percentages of Selected Groups Expressing Interest in Science as a Career on Six Questions, Ages 13 and 17



very similar. Both groups seemed aware of the benefits of a scientific education, especially in terms of jobs, but appeared concerned about the cost of such an education.

TABLE 4. Percentages of Responses to Questions About Scientific Education and Training, Ages 13 and 17

For me, the education and training needed to prepare me to work in a scientific field would

	Age 13	Age 17
A. Cost too much money Definitely or probably not	26%	27%
B. Be worth it in the long run Definitely or probably yes	57	55
C. Open many job opportunities for me Definitely or probably yes	63	64
D. Be worthwhile, even if I didn't go into a scientific field Definitely or probably yes	55	54

Feelings of teenaged males and females about the benefits of scientific training were similar. At age 17, blacks appeared more convinced than whites of such benefits.

Summary of Group Results

For 13-year-olds, differences in vocational and educational aspirations were somewhat more marked than differences in attitudes toward science classes. Blacks, those living in the Southeast and those from disadvantaged-urban communities were more favorable to scientific vocational and educational aspirations than the nation as a whole. Males displayed more favorable attitudes toward scientific careers than females. Those living in advantaged-urban communities were considerably *less* likely than the nation to express favorable views on educational and vocational aspirations in science.

The patterns seen for 17-year-olds on these questions were very similar to their results on questions about attitudes toward science classes. Males were more positive about scientific educational and vocational intentions than females. Blacks, those living in the Southeast and those living in disadvantaged-urban communities exhibited more favorable attitudes than the nation as a whole, while whites, those living in extreme-rural communities and those whose parents had graduated from high school expressed less favorable attitudes than the nation.

Experiences With Science-Related Activities

Although science is sometimes considered a textbook subject, consisting of facts and formulas to be memorized, it should be a process of discovery, requiring an open mind and a willingnesss to challenge accepted answers. However, this attitude is not fostered solely by reading about the discoveries of others or memorizing scientific facts. One must have the opportunity to experiment and to experience things for oneself.

Learning builds upon one's background of experience. Therefore, it is important to see what experiences children of different ages and different population groups bring to their science classes and what experiences with science they have had at different points in their educational development.

Age 9 Results

Nine-year-olds were first asked about their participation in various activities and then asked whether they would like to participate in such activities.

Most 9-year-olds (87%) had visited a zoo and many (71%) had visited a museum.

Approximately one-third had been to a planetarium, and about one-fifth had visited a weather station. Relatively few (under 15%) had been to an electric generating plant or a sewage treatment plant.

Males were more likely than females to have visited a planetarium, electric generating plant, sewage treatment plant or weather station, while percentages having visited a museum and a zoo were similar for males and females. Fewer blacks than whites had visited a museum or zoo; however, more blacks than whites said they had visited a weather station. Nine-year-olds living in the Southeast were considerably below the national average in visiting zoos or museums.

Many more children said they would like to visit the various places listed than had actually done so. For example, 32% had visited a planetarium, but 71% said they would like to; 71% said they had visited a zoo, but 92% expressed a desire to do so; 21% had visited a weather station, but 85% wanted to visit one.

Things that they had seen first-hand — not on television or in a book — were the subject of another series of questions for 9-year-olds (Exhibit 5). Again, more 9-year-olds expressed a desire to see the things listed than had actually seen them. The largest percentages wanted to see an egg hatching, birds caring for their young and the moon through a telescope.

Nine-year-olds were also asked if they had done various science-related activities. Results showed that:

- Eighty-three percent had collected leaves, flowers or insects; 71% had taken care of an aquarium or fish bowl.
- Seventy-one percent had taken something apart to see how it worked.
- Sixty percent had touched a snake or lizard.
- Thirty-eight percent had taken their own temperature and 28% had taken their own pulse.

Between 80 and 90% of the 9-year-olds had used a scale, a magnifying glass, a thermometer, a yardstick and a calculator. Slightly over half (52%) had used a microscope, while 42% had used a meterstick and 43% had used a telescope.

More students said they would like to use the instruments than actually had — on the average, 76% said they would like to use them, compared with 65% who had actually used them.

Children were also asked if they had done experiments or activities with various objects. The question was not limited; the activity could have been done at home or in school.

The assessment found that:

- Approximately 70% of the 9-year-olds had experimented with living plants and with dissolving things in water.
- Fifty-six percent had experimented with seeds; 55% said they had experimented with living animals.
- Fifty-five percent had experimented with magnets, and 51% had worked with batteries and bulbs.

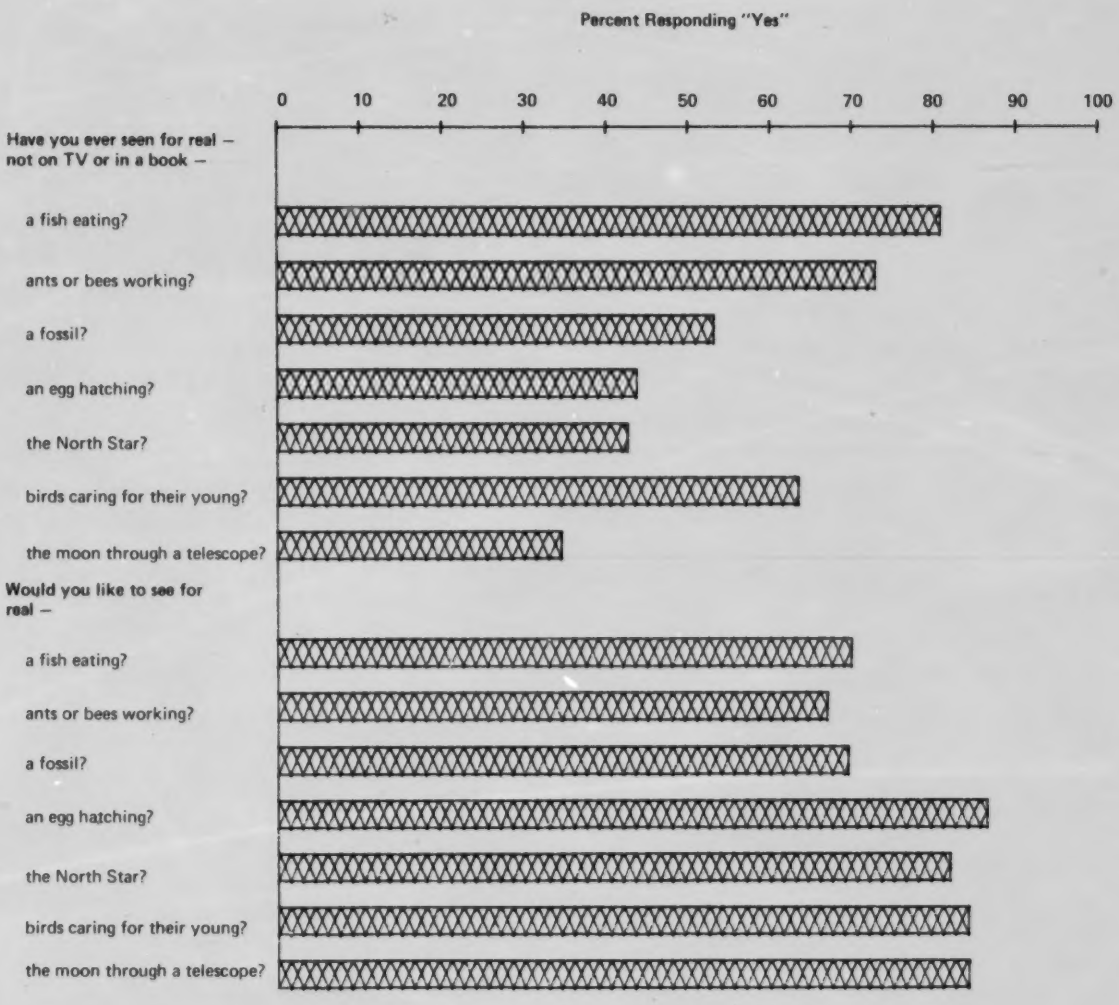
More children said they would like to experiment with the items listed than had actually done so. The greatest enthusiasm was seen for experimenting with living plants and animals, seeds and magnets.

Ages 13 and 17 Results

Questions about science-related experiences asked of 13- and 17-year-olds covered the same topics as for 9-year-olds; however, the teenagers responded to a more extensive set of questions.

To gain insight into the general level of

EXHIBIT 5. Percentages of 9-Year-Olds Who Have Seen Various Things First-Hand and Who Would Like to See Them First-Hand



students' experiences, the assessment questioned them about visits to very common places as well as visits to places more closely connected with science.

Nearly everyone had visited a hospital, a doctor's office, a park, and a pond or lake. High percentages (over 90%) had visited a zoo, a farm, a museum, a large city, a river and an airport. Sixty-five percent of the 13-year-olds and 74% of the 17-year-olds had visited the ocean; 20% and 33% at ages 13 and 17, respectively, had seen a desert.

Following are percentages of teenagers who had visited places more directly related to science:

	Age 13	Age 17
Visited an electric generating plant	27%	40%
Visited a sewage treatment plant	17	26
Visited a scientific laboratory	19	32
Visited a factory	80	86
Visited a planetarium	55	67

More males than females had visited the various places, although by age 17 the discrepancies appeared to be lessening. Large differences between blacks and whites existed in visiting fairly common places, especially places in the out-of-doors. For example, 91% of white 13-year-olds and 95% of white 17-year-olds had visited a forest; for blacks, these percentages dropped to 68% and 73%. Roughly 20% fewer blacks than whites at either age had visited an ocean or a mountain.

Regional differences varied widely depending on the nature of the subject being asked about. Many more of those living in the West had visited a mountain and a desert than had those in other regions; those living in the Northeast were more likely to have seen an ocean.

Thirteen- and 17-year-olds were also asked about things they had seen first-hand — not on television or in a book. Generally, more 17-year-olds than 13-year-olds had seen them (Exhibit 6).

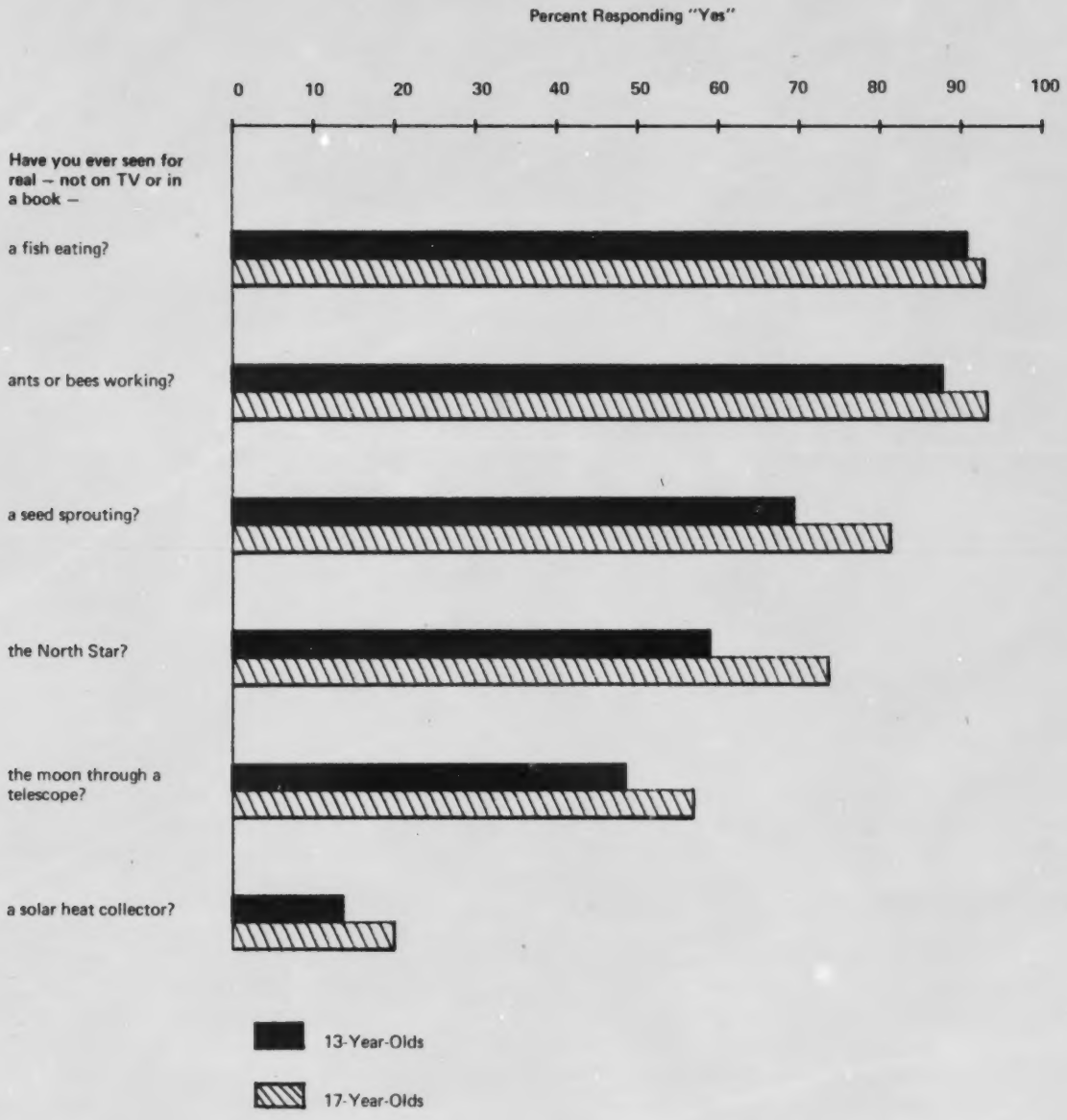
Activities associated with science that teenagers had done were the subject of another series of questions. Following are samples of their experience levels:

- Eighty-three percent of the 13-year-olds and 95% of the 17-year-olds had focused a microscope by themselves.
- Seventy percent of the 13-year-olds and 85% of the 17-year-olds had taken their own temperature.
- Fifty-eight percent at age 13 and 70% at age 17 had experimented with something for more than a week to see how it changed.
- Fifty-two percent at age 13 and 58% at age 17 had wired together an electrical circuit.
- Thirty-nine percent and 67% of the 13- and 17-year-olds, respectively, had made a microscope slide.
- Twenty-six percent of the 13-year-olds and 32% of the older group had made a magnet using electricity and wire.

Many students had taken care of animals, grown plants, taken care of fish or aquariums, and collected leaves, flowers or insects.

There were large differences between males and females participating in activities having to do with electricity. At age 13, 71% of the males and 34% of the females had wired together an electric circuit; at age 17, 82% of the males and 34% of the females had done so. Thirty-nine percent of the 13-year-old males and 14% of the females had made a magnet using electricity and wire, while at age 17, 50% of the males and 14% of the females had done so. Females at both ages were more likely than males to have collected leaves, flowers or insects.

EXHIBIT 6. Percentages of 13- and 17-Year-Olds Who Have Seen Various Things First-Hand



Questions concerning the use of scientific instruments showed that nearly everyone (over 95%) had used common instruments such as a yardstick, measuring cup, thermometer, camera, magnifying glass, scale and calculator. Most students had used a microscope (89% of the 13-year-olds and 98% of the 17-year-olds) and a meter stick (70% at age 13 and 79% at age 17). Thirty-two percent of the 13-year-olds and 64% of the 17-year-olds had used a graduated cylinder; 23% and 37% at ages 13 and 17, respectively, had used a meter that measures electricity. Only 5% of the 13-year-olds and 11% of the 17-year-olds had ever used a pollution detection kit.

Teenagers were also asked if they had worked with or experimented with various items. Some examples are shown in Exhibit 7. Many teenagers had experimented with seeds, living plants and magnets; fewer had done experiments with electricity, chemical reactions and waves. Close to one-fourth at each age said they had worked with solar energy. On the average, approximately 10% more 17-year-olds than 13-year-olds had experimented with the various items listed.

Summary of Group Results

Group differences in science-related experiences followed patterns somewhat different from those seen in the previous sections. Blacks and those living in disadvantaged-urban communities reported fewer science-related experiences than the national average, and the disparity increased with age. Blacks were 5 percentage points below whites at age 9, 8 percentage points below them at age 13 and 11 percentage points below them at age 17. Disadvantaged-urban students were 4 percentage points below the nation at age 9, 7 percentage points below at age 13 and 10 percentage points below at age 17.

Experiences appeared related to grade in school. Those in a higher grade for their age level reported more experiences than those in a lower grade level.

The Southeastern region was approximately 3 percentage points below the nation at each age level. The other regions did not differ greatly from the national average.

Other groups followed patterns similar to those found in the previous sections. Males consistently had more science-related experiences than females; at all three ages, males' average was 4 to 5 percentage points above that of females.

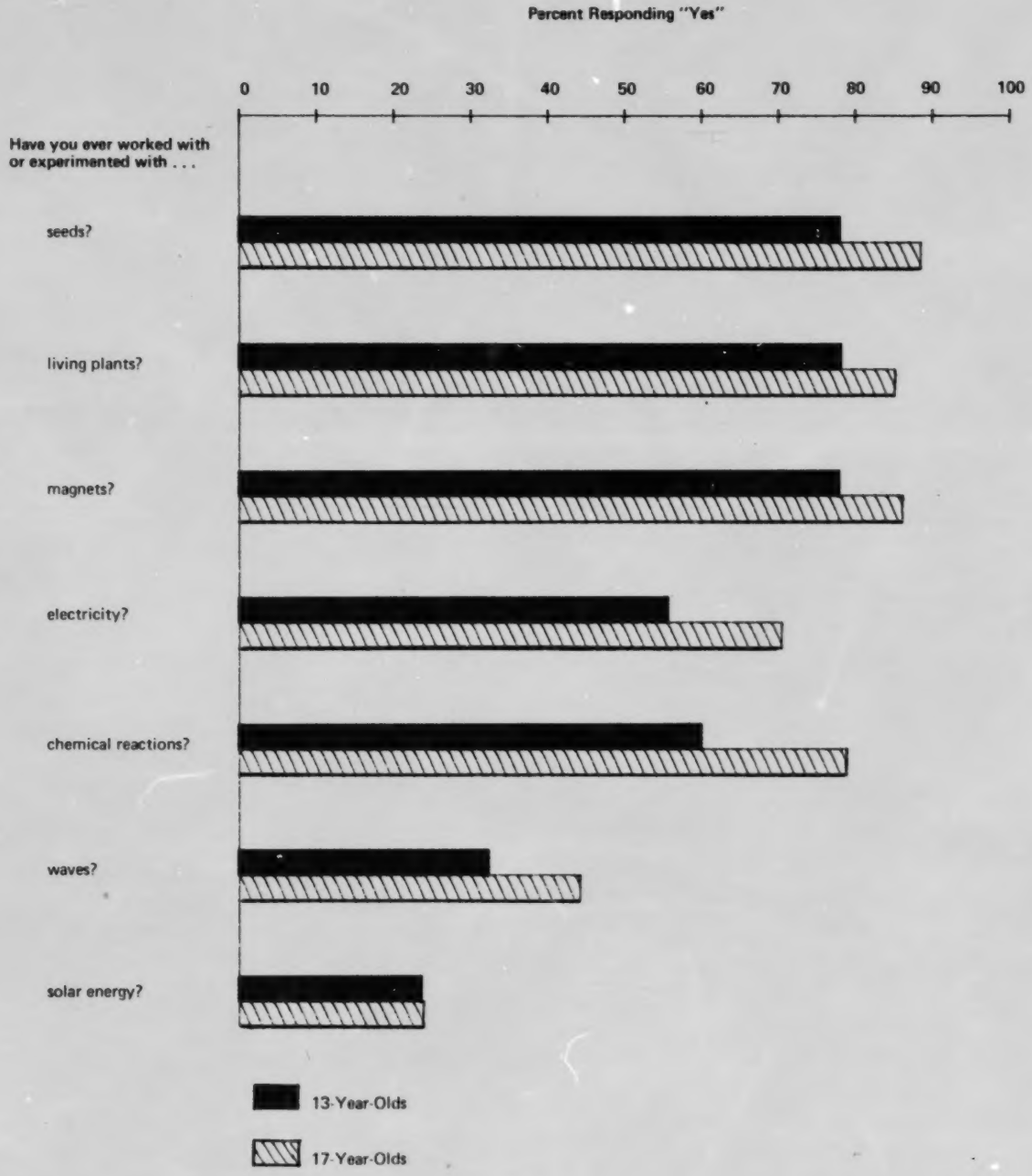
Those whose parents had not graduated from high school were below the national level. Those whose parents were high school graduates were either at or slightly below the nation, and those whose parents had some education beyond high school reported more science-related experiences than the national average.

Nine-year-olds living in extreme-rural areas had visited fewer places than the national average; disadvantaged-urban 9-year-olds were above the national level. On questions about things seen, done or used, responses of extreme-rural 9-year-olds were similar to the national average, while disadvantaged-urban children were below it.

For 13- and 17-year-olds, students in the Northeast generally were more likely than the nation as a whole to have used scientific instruments and to have done various experiments. Extreme-rural students at these ages had visited fewer places than the national average, and 13-year-olds from extreme-rural areas were below the nation in the number of scientific instruments used; otherwise, extreme-rural students reported experiences similar to those of the nation as a whole.

It is interesting to compare the group differences described in this section with those described in the two preceding sections. Experiences seem to follow the same patterns seen in many areas of cognitive knowledge measured by National Assessment (Johnson, 1975), while on attitudes toward science education and scientific aspirations, those from some typically lower-achieving groups

EXHIBIT 7. Percentages of 13- and 17-Year-Olds Who Have Experimented With Various Things



evidenced more attitudes designated as "favorable" than those from typically higher-achieving groups.

Personal Use of the Tools and Attributes of Science

Scientific advances require people with an inquiring mind, people who are challenged by the possibility of discovering the unknown. To investigate attitudes toward problem-solving, National Assessment questioned students about the methods they use in attacking problems.

Age 9 Results

Nine-year-olds responded to four questions about their feelings toward solving problems. Most (92%) said they feel good when they find out something new on their own. Many (85%) said they tried to think of different ways to solve problems. Sixty-one percent said they would rather not be told an answer but would rather find it out for themselves, while 34% said they would rather be told the answer. Only 19% said they usually like questions they did not know the answer to; 77% said they did not like such questions.

Substantial differences between sexes were apparent on only one of these questions — more males than females would rather be told the answer to a question than find out the answer on their own. More blacks than whites at age 9 preferred being told an answer to finding it out on their own, and blacks were less likely than whites to try to think of different ways to solve problems.

Advantaged-urban children were considerably below the nation in their liking for questions to which they did not know answers. Extreme-rural students were less likely to want to be told answers than the nation as a whole.

Ages 13 and 17 Results

It appears that use of scientific problem-solving methods does not change very much between ages 13 and 17. One series of questions asked teenagers about the methods they use to gather information and reach decisions; results for some of these questions are shown below. Percentages responding positively to this series of questions were slightly over half at each age level — 53% at age 13 and 54% at age 17.

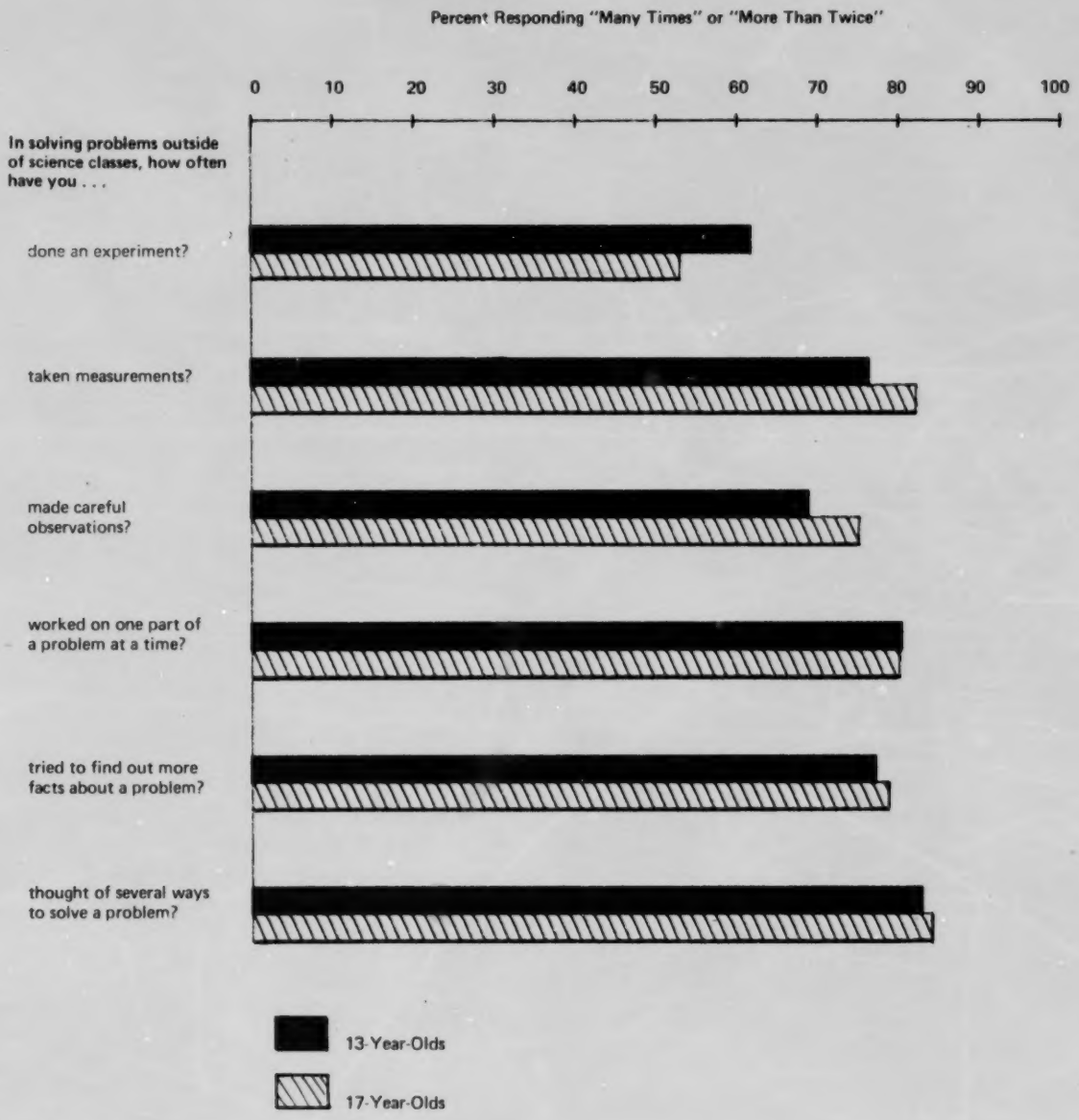
	Percent Responding Always or Often	
	Age 13	Age 17
Do you think it is important to look at all sides of a question before you make a decision?	78%	80%
How often do you like to try to figure out how things work?	69	65
When you find out that your ideas don't fit the facts, do you change your mind?	45	38
How often do you keep working on a task even if you run into problems that you didn't expect?	52	61
How often do you gather a variety of information before you make a decision?	45	47

Teenagers were also asked about specific steps they had taken to solve problems outside of science classes (Exhibit 8). An average of approximately 75% at both ages 13 and 17 had done the activities listed fairly often. The overall similarity between 13- and 17-year-olds' responses is again noteworthy.

Summary of Group Results

Group differences were generally small for

EXHIBIT 8. Percentages of 13- and 17-Year-Olds Who Have Used Various Scientific Problem-Solving Techniques



teenagers. Averages for both 13- and 17-year-old males on this section were slightly above those for females. At age 13, whites' average was slightly above that for blacks, but by age 17, results for the two groups did not differ significantly.

For 17-year-olds, grade level in school appeared related to use of the tools and attributes of science. Those in the 10th grade were 5 percentage points below the national level; 11th graders were close to the national average, and 12th graders were 4 percentage points above the nation. For 13-year-olds, grade in school did not appear to be strongly related to results on this section.

CHAPTER 2

SCIENCE AND SOCIETY

Public attitudes have an influence on the progress of science and technology in the United States. Attitudes may directly affect voting on particular issues or candidates and young people's interest in entering scientific careers. Indirectly, public opinion may influence governmental direction, funding and regulation of research activities. Without a climate of popular support, free scientific inquiry could be threatened.

This chapter examines young Americans' perceptions of the relationship between science and society, specifically dealing with their confidence in science to solve science-related societal problems, their support for research, both basic and applied, their opinions about research on controversial topics and their personal willingness to help solve science-related societal problems.

Questions concerned with confidence in science, support for research and opinions about controversial research were asked of young adults, ages 26—35, as well as of 13- and 17-year-olds. Nine-year-olds did not respond to any questions in these areas. Questions about personal involvement with science-related societal problems were addressed to 9-, 13- and 17-year-olds only.

Many of the questions reported on in this chapter have no "right" answers. Results describe attitudes currently held by young Americans, and future assessments will provide information on any changes in these attitudes over time.

Confidence in Science

To be able to compare National Assessment results with data from another source, the science assessment included six questions used by the National Science Board (NSB) as part of their Science Indicators series to investigate public attitudes toward science and technology (National Science Board, 1976, pp. 168—182). The questions examined general reactions to science and feelings about the ability of science to solve problems, the rate of change caused by science, problems caused by science and the amount of control society should have over science.

The following discussion presents data on these questions from both the NAEP and NSB surveys. In comparing results, several considerations should be kept in mind. First, National Assessment administered these questions to 13- and 17-year-olds as well as to adults ages 26—35, while the National Science Board survey included adults age 18 and older. Thus, composition of the adult age groups was not identical. Next, the NSB data presented here were collected in September 1976. National Assessment data for 13- and 17-year-olds were collected during the 1976—77 school year, and adult data were gathered during the spring and summer of 1977, so administration dates of the two surveys differed, but only by less than a year.

The following question elicited respondents' general reactions to science and technology:

Which of these items best describes your general reaction to science and technology?

	Fear or Alarm	Satisfaction or Hope	Excitement or Wonder	Indifference or Lack of Interest	No Opinion
Age 13	2%	22%	40%	21%	16%†
Age 17	3	28	36	23	10
Adults 26–35	3	41	37	10	8†
Adults 18 or older (NSB survey)	6	55	23	9	7

†Figures do not total 100% due to rounding.

At ages 13 and 17, the largest percentages of respondents chose "excitement or wonder" as their reaction, while both groups of adults were more likely to answer "satisfaction or hope." A substantial portion of the teenagers — slightly over one-fifth — reacted to science with indifference or lack of interest. When these percentages are added to those expressing no opinion, around one-third of the 13- and 17-year-olds expressed either no opinion or indifference about science. Adults were far more likely to express positive feelings than either 13- or 17-year-olds.

Another question concerned the ability of science to solve problems (Exhibit 9). Confidence in the ability of science to solve most or some of our problems was fairly high. A majority of the National Assessment survey respondents at each age felt that science would eventually solve some of our problems, and approximately 20% at each age felt that science would at some time solve *most* of them. In contrast, respondents to the National Science Board survey expressed more extreme opinions than the other groups. More felt that science would solve most problems, and more felt that science would solve few problems.

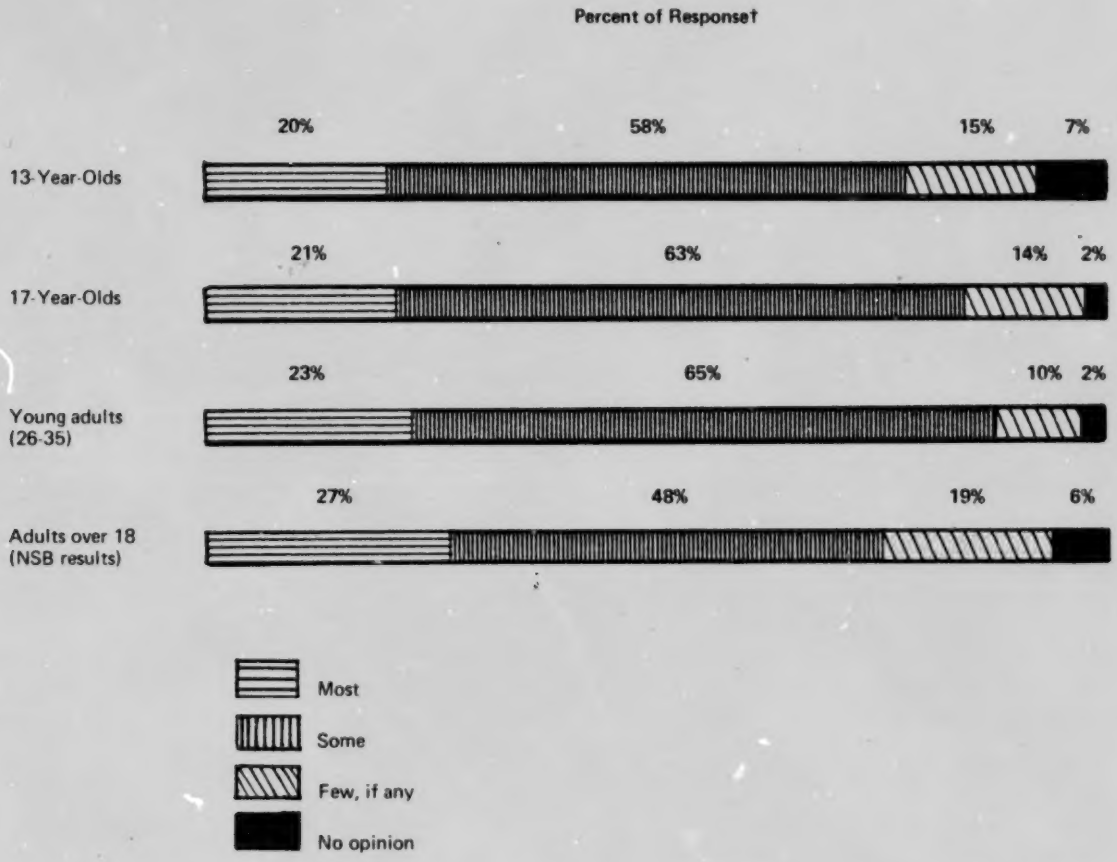
When asked if science and technology have changed life for the better or the worse, those in the NSB sample were overwhelmingly more likely than the NAEP groups to say that life had changed for the better; 71% of the NSB group said life had changed for the better, compared with 36% of the 13-year-olds, 37% of the 17-year-olds and 56% of the NAEP young adults. The younger groups were more likely to respond that science and technology have changed life *both* for the better and for the worse — 46% of the 13-year-olds, 52% of the 17-year-olds and 36% of the younger adults gave this response, while only 12% of the NSB group did so.

Feelings about the rate of change brought about by science and technology were also investigated. Sixty percent of the 13-year-olds, 48% of the 17-year-olds, 40% of the younger adults and 53% of the adult NSB group felt that the rate of change was just about right. Twenty percent at age 17 and 23% of each of the adult groups felt that the rate was too fast. Fairly larger percentages of the NAEP groups — approximately 15 to 20% — had no opinion on this question; 8% of the NSB group, in comparison, expressed no opinion.

Many people recognized that science and technology could cause problems as well as solve them (see Exhibit 10). Pessimism was higher for young adults and 17-year-olds than for 13-year-olds or the adults in the National Science Board study. Approximately 60% of 17-year-olds and younger adults felt that science had caused most or some of our problems. Adults surveyed by NSB were more likely than the other groups to feel that science has caused none of our problems.

EXHIBIT 9. Percentages of Response Regarding Ability of Science and Technology To Solve Problems, Ages 13, 17, Young Adults and NSB Results

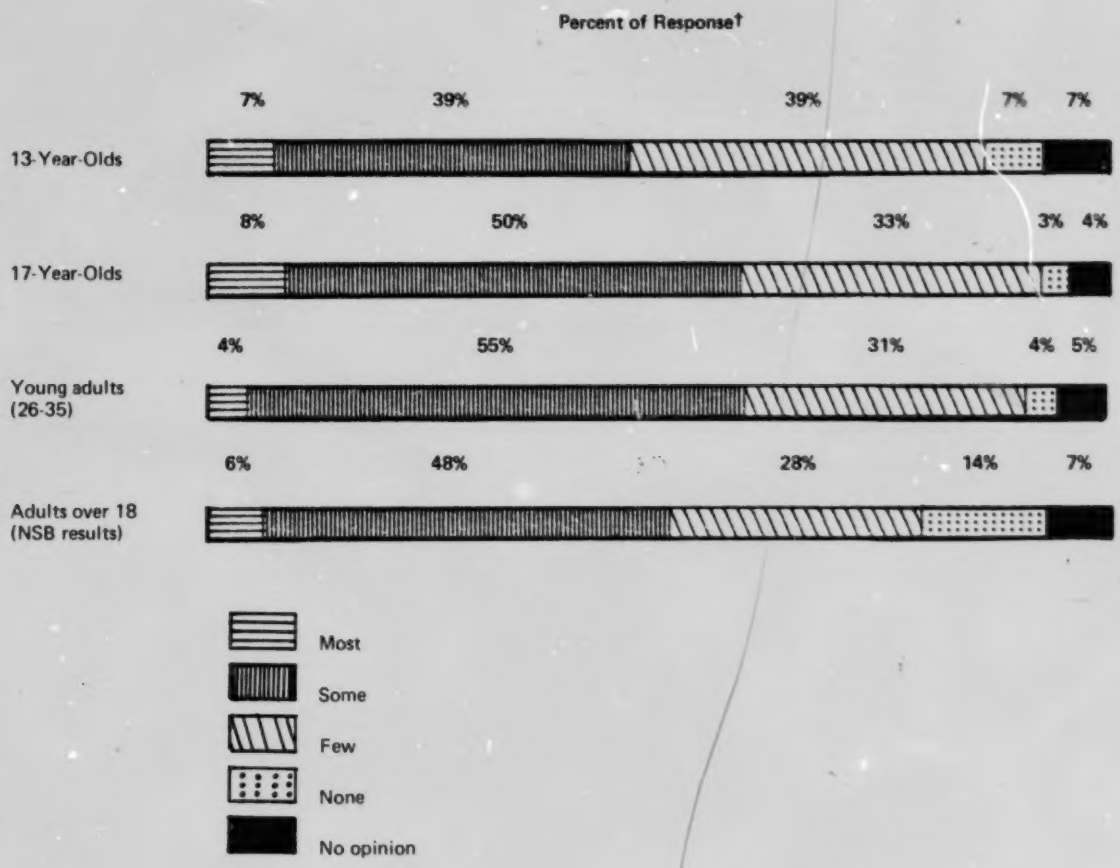
For the most part, do you feel that science and technology will eventually solve *most* problems such as pollution, disease, drug abuse and crime, *some* of these problems, or *few if any* of these problems?



†Percents have been rounded to the nearest whole number.

EXHIBIT 10. Percentages of Response Regarding Extent of Problems Caused by Science and Technology, Ages 13, 17, Young Adults and NSB Results

Do you feel that science and technology have caused *most* of our problems, *some* of our problems, a *few* of our problems, or *none* of our problems?



†Percents have been rounded to the nearest whole number, so some rows might not total 100%.

This final question asked about societal control over science and technology:

> Do you feel that the degree of *control* that society has over science and technology should be increased, decreased, or remain as it is now?

	Increased	Decreased	Remain As It Is	No Opinion
Age 13	26%	11%	42%	21%
Age 17	29	10	40	21
Adults 26–35	35	11	38	16
Adults 18 or older (NSB survey)	31	10	45	14

The largest percentage in each group thought that things should remain as they are. However, the next largest percentage in each group felt that societal controls should be increased. Percentages favoring more control increased with age through the younger adult group and then dropped off somewhat for the NSB group of all adults.

Attitudes reported on these questions varied considerably by age group. On questions concerning general reactions to science and technology and whether science has changed life for the better or for the worse, both groups of adults gave much more positive responses than the teenaged groups. The percentage feeling that science had changed life for the better also increased dramatically between the young adults surveyed by National Assessment and the adults surveyed by the National Science Board. In general, pessimism on questions about the rate of change brought about by science, the amount of control needed for scientific endeavors and the extent to which science causes problems increased from ages 13 to 17 to young adult. The NSB adults evidenced less pessimism on these questions, generally falling between the 13- and 17-year-olds' levels of response. However, the NSB adults were less confident than the other groups about the ability of science and technology to solve problems.

Demographic information on these questions is provided only for National Assessment survey respondents, because group categories used in the two surveys differed.

At all three ages surveyed — 13, 17 and young adult — males were more likely than females to regard science with a sense of wonder. At ages 13 and 17, more females than males regarded science with indifference or a lack of interest. At the adult level, females were more likely to express hope while males expressed wonder; slightly more females than males at this age still expressed a lack of interest or indifference. At age 17, 34% of the extreme-rural students, compared with 23% of the nation as a whole, regarded science with indifference. Among the young adults, those with higher levels of personal education, higher amounts of training in science or science-related jobs were more likely to regard science with wonder. Less formally educated groups were more likely to express no opinion on the subject.

At all three ages, blacks were more likely than whites to feel that science could solve few of our problems. Adults who had had some science training or science-related jobs were more confident about the ability of science to solve problems than those who had not.

Seventeen-year-old blacks were more likely than whites to feel science had made no changes in their lives or to express no opinion on the subject, rather than believing science

had changed their lives either for better or worse. Adult blacks were more likely than whites to express no opinion on the subject.

More teenaged males than females felt science has caused most or some of our problems; females at these ages were more inclined to state that science has caused few of our problems. Those adults with science training or science-related jobs were more likely to believe science had caused some of our problems than those without such experience.

As another indicator of confidence in science, a series of questions asked 13- and 17-year-olds and adults whether they thought science could help "none," "some" or "very much" in solving various societal problems.

Confidence in the power of science to solve problems appeared very closely tied to the particular problem being discussed, as shown in Exhibit 11, and generally increased with the age of the respondents. Relatively high percentages felt that science could help very much in finding cures for diseases and in saving us from energy shortages. Relatively few at any age felt science could help very much in controlling weather or preventing wars.

Support for Research

Support for research was measured by two series of questions — one concerned with support for applied research, the other with support for basic research.

Applied research topics were rather loosely defined as things having fairly obvious and more or less immediate practical application. Basic research topics, while perhaps not as "basic" as some of the research conducted in the nation's university and industrial laboratories, were topics for which applications were not as direct or apparent as for those listed under applied research.

Support for both basic and applied research increased with the age of the respondents, and at each age support for applied research was higher than for basic research. Table 5 shows average percentages of support for applied and basic research. By far, the majority at each age expressed support for both kinds of research.

TABLE 5. Average Percentages Supporting Applied and Basic Research, Ages 13, 17 and Adult

Should scientists be given money to study . . .

	Percent Responding Definitely or Probably Yes		
	Age 13	Age 17	Adults
Applied research (19 questions)	76	83	88
Basic research (16 questions)	67	72	76

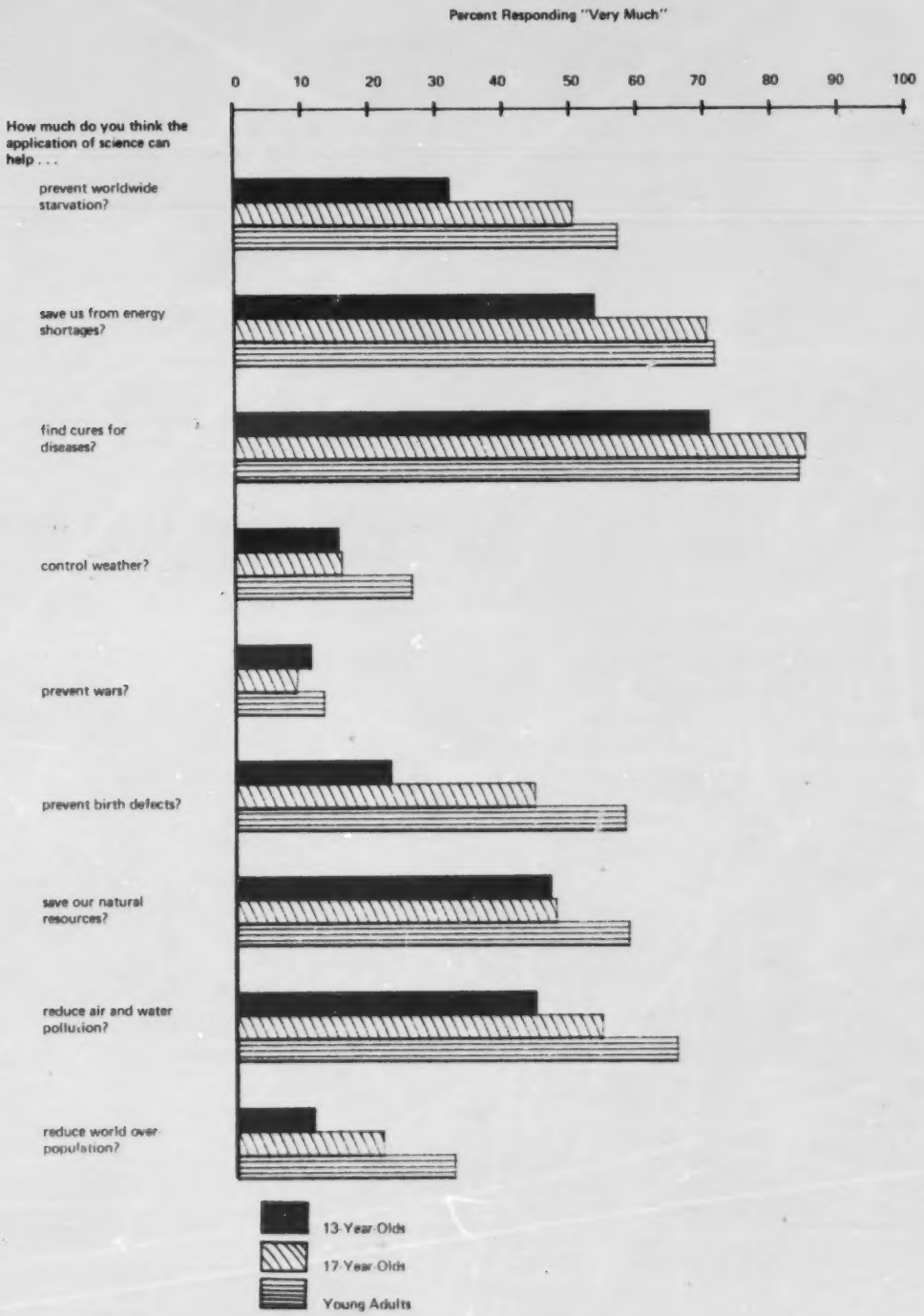
In response to questions about applied research, over 95% at each age level felt scientists should be given money to study cures for cancer, methods of reducing air pollution and ways to solve energy problems. Over 90% at each age felt money should be given to scientists to study ways to predict earthquakes, produce more food, develop low-pollution electric transportation systems and use solar energy.

Substantial majorities at each age supported research on the following topics:

Do you think scientists should be given money to study

	Percent Responding Definitely or Probably Yes		
	Age 13	Age 17	Adults
Ways to cure a very rare disease	81%	86%	94%
How to prevent droughts	71	83	89
Methods of birth control	70	81	84
Methods of farming the oceans	61	78	80

EXHIBIT 11. Percentages of 13-Year-Olds, 17-Year-Olds and Young Adults Believing That Science Can Help "Very Much" in Solving Various Problems



Support was considerably lower for research into the behavior of people who live in crowded cities (supported by 34% of the 13-year-olds, 46% of the 17-year-olds and 69% of the adults) and for research on new ways to build smokestacks (supported by 20% at age 13, 26% at age 17 and 39% at the young adult level). People evidently did not recognize that smokestacks can play a role in air pollution.

In answering questions about more basic research topics, over 90% were most supportive of research into things that "may be useful someday" and into efficient, lightweight ways of storing electrical energy. Exhibit 12 shows percentages of support for some representative topics.

Few people felt that money should be given to study things that "probably will never be useful" — 26% of the 13-year-olds, 16% of the 17-year-olds and 23% of the adults responded affirmatively to this question.

When results on support for both types of research were summarized, differences among groups were found to be fairly small at ages 13 and 17. Differences were larger, however, for adult groups. Males were more supportive of research than females, by an average of 5 percentage points. The average percentage for adult blacks was 9 percentage points below that for whites.

Adults' personal experiences appeared related to their support for research. Adults who had not graduated from high school were 8 percentage points below the average national level of support, while those with some education beyond high school were 5 percentage points above the nation. Those who had had some science-related training performed above the national level while those who had not were below it; similarly, those with science-related jobs expressed more favorable attitudes toward scientific research than those who did not have such jobs.

A series of questions administered in both the 1972–73 and 1976–77 assessments asked 17-year-olds about their approval or disapproval of various types of research. Support for some types of research went up slightly while support for others declined somewhat, resulting in about the same average level of support in each assessment year. For example, the percentage supporting space exploration increased from 70% to 78%, while the percentage approving of atomic energy research declined from 72% to 69%. Approximately 73% supported research on modification of inherited traits in humans, 95% approved of research into air and water pollution, 66% approved of study of the origins of the universe and 77% approved of research into population control, in each assessment year.

Support for Research Into Controversial Issues

Do people believe that scientists should be free to research anything they want to or do they think that there should be some limitations placed on subjects for research? The research topics discussed in the previous section were, in the main, topics that most people would agree would show beneficial, or at least neutral, results. The topics dealt with in this section are more obviously and immediately connected with implications for human life — developing life in test tubes, creating identical replicas of people and researching ways of controlling people's actions.

Adults were generally less willing than 13- or 17-year-olds to support research into controversial issues, as shown on page 35.

Percentages of respondents feeling that scientists should be allowed to grow living things from test-tube beginnings varied with the type of life being considered, as seen in Exhibit 13.

Adults were also less likely than the younger age groups to feel that scientists should be allowed to create life — 44% at age 13, 36% at age 17 and 22% of the adults said scientists should be allowed to try to create life, while 40%, 50% and 64% at ages 13, 17

EXHIBIT 12. Percentages of 13-Year-Olds, 17-Year-Olds and Young Adults Supporting Basic Research on Various Topics

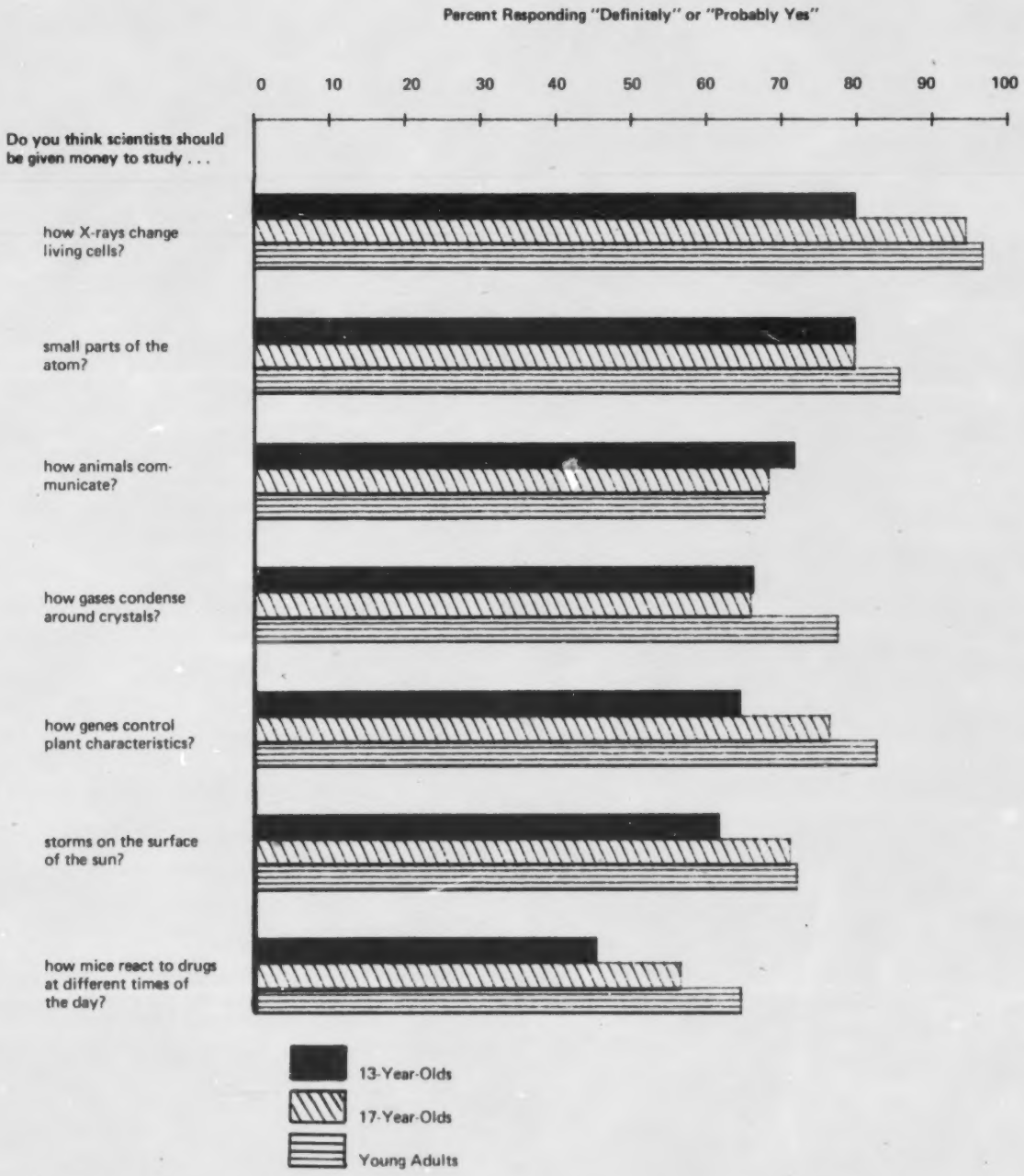
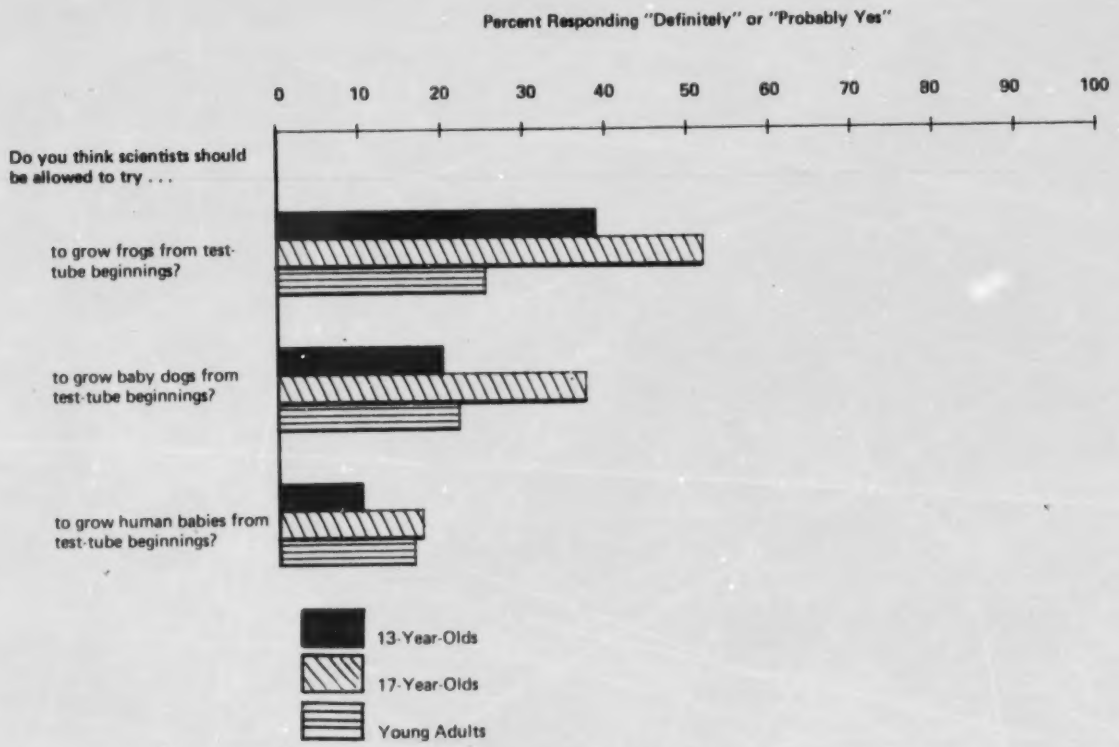


EXHIBIT 13. Percentages of 13-Year-Olds, 17-Year-Olds and Young Adults Expressing Opinions on Beginning Life in Test Tubes



Do you think scientists should be allowed to try . . .	Age	Definitely or Probably Yes	Not Sure	Definitely or Probably Not
To make bigger bombs?	13	38%	14%	48%†
	17	27	10	62†
	Adult	13	12	74†
To grow exact copies of people?	13	12	12	76
	17	8	9	83
	Adult	7	9	83†
To do any kind of research they want to do?	13	30	19	51
	17	33	20	47
	Adult	13	15	72
To seek other forms of life in space?	13	86	8	6
	17	87	6	7
	Adult	61	15	23†

†Figures do not total 100% due to rounding.

and adult, respectively, felt that they probably or definitely should not.

The series of questions following was administered only to 13- and 17-year-olds.

How often do you think scientists should be allowed to

	Always or Often	Sometimes	Seldom or Never
A. Experiment on people without their approval?			
Age 13	3%	10%	87%
Age 17	1	7	92
B. Create new diseases for warfare?			
Age 13	7	11	82
Age 17	3	6	91
C. Work on secret projects?			
Age 13	28	45	27
Age 17	22	48	30
D. Control the way people act?			
Age 13	9	13	78
Age 17	2	12	86

Personal Involvement With Science-Related Societal Problems

The previous section examined people's attitudes toward science in society, probing their confidence in science and their support of research. This section is concerned with personal involvement — a belief that individual actions can make a difference in solving societal problems and a willingness to act upon that belief.

These questions were asked of 9-, 13- and 17-year-olds who were attending school at the time of the assessment.

Age 9 Results

Nine-year-olds were asked if they felt the following things were serious problems in the world today: pollution, energy waste, food shortages and disease. Most 9-year-olds felt that pollution, energy waste and disease are serious problems — 93% responded that pollution is a serious problem, 85% said that energy waste is serious and 84% stated that disease is serious. Fewer (58%) felt food shortage to be a serious problem.

Nine-year-olds also were asked if there was anything they could do to help solve these four problems. A majority of the 9-year-olds felt they could do something about pollution and energy waste, which most of them thought were serious problems. Seventy-four percent said they could do something about pollution, and 71% felt they could help solve energy waste. About half felt they could help with the problem of food shortages, and fewer (41%) felt they could help solve problems of disease.

Another series of questions asked 9-year-olds if they would be willing to do certain things to help solve problems, even though it might cause them some inconvenience. Most 9-year-olds were willing to suffer some personal inconvenience to help solve science-related societal problems (Table 6).

TABLE 6. Percentages of 9-Year-Olds Willing To Perform Various Conservation Activities

Which of the things below would you be willing to do to help solve world problems, even if it is inconvenient? Would you be willing to . . .

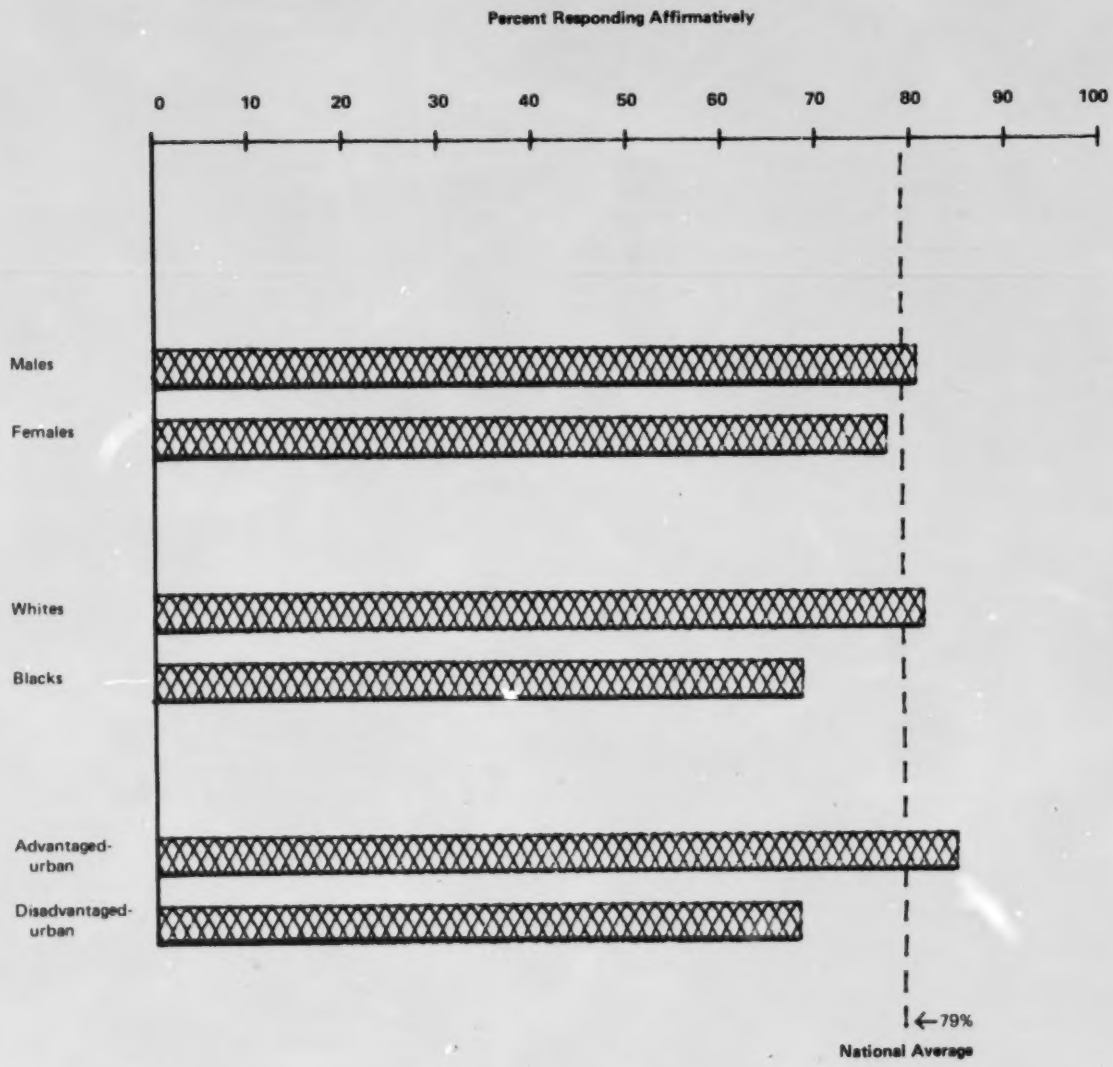
		Percent Responding Yes
A.	Use less electricity?	91
B.	Spend a day helping clean up litter from a street, park or road?	86
C.	Use returnable bottles rather than "throw-away" bottles?	84
D.	Walk and ride bikes more often?	79
E.	Separate trash (bottles, cans, paper, etc.) for recycling?	75
F.	Use less heat in the winter to save fuel?	73
G.	Drive or ride in a small economy car?	52

Different groups displayed different degrees of willingness to help with the activities listed (Exhibit 14). For example, 19% fewer 9-year-old blacks than whites were willing to use less electricity; 17% fewer were willing to walk or ride bikes more often; 8% fewer were willing to drive or ride in small economy cars. In most cases, advantaged-urban students were more willing than the nation as a whole to perform the activities listed; however, this group was not more willing to drive small economy cars or use returnable bottles.

Ages 13 and 17 Results

Thirteen- and 17-year-olds responded to some of the same questions asked of 9-year-olds. As the table shows, 13-year-olds were generally less optimistic than 9- and 17-year-olds that they could do anything to help with

EXHIBIT 14. Average Percentages of Selected Groups Willing to Perform Various Conservation and Energy-Saving Activities, Age 9



the problems of pollution, energy waste, food shortages and disease.

	Yes	Definitely or Probably Yes	
	Age 9	Age 13	Age 17
Can you help solve the problems of:			
Pollution	74%	67%	77%
Energy waste	71	60	70
Food shortages	50	47	55
Disease	41	31	31

All groups felt they were more likely to be able to help fight pollution and energy waste than food shortages and disease.

On other questions, similar percentages of 13- and 17-year-olds — 36% at age 13 and 40% at age 17 — felt they could help with the problem of running out of natural resources. Seventeen-year-olds were much more likely than 13-year-olds to believe they could help with the problem of overpopulation — 54% of the 17-year-olds responded in the affirmative, compared with 23% of the 13-year-olds.

Thirteen- and 17-year-olds were asked to indicate whether they were willing to undertake certain activities to help with societal problems, even if it might cause them some inconvenience. These questions were identical to those asked of 9-year-olds. Exhibit 15 displays percentages of teenagers willing to participate in various activities.

Willingness to take part in such activities proved far higher than actual participation. While about 90% of the 13- and 17-year-olds said they would be willing to use less electricity, only 57% of the 13-year-olds and 68% of the 17-year-olds said that they always or often turn out lights they do not need.

Nearly 70% at each age were willing to spend a day helping to pick up litter. Twenty-six and 28% of the 13- and 17-year-olds, respectively, said they often or always pick up litter, and an additional 42% of the 13-year-olds and 44% of the 17-year-olds stated that they sometimes do. On another question, 42% of 13-year-olds and 36% of 17-year-olds said they had participated in a litter clean-up project more than once or twice.

Approximately 65% of the 13- and 17-year-olds stated that they would be willing to separate trash for recycling; however, only 29% of the 13-year-olds and 23% of the 17-year-olds said that they had actually done so more than once or twice. Forty-eight percent of the 13-year-olds and 54% of the 17-year-olds said that they had never separated trash for recycling.

Teenagers living in the West were more likely to have separated trash than those living in other regions. This may reflect the fact that more Western states have laws concerning the recycling of cans and bottles.

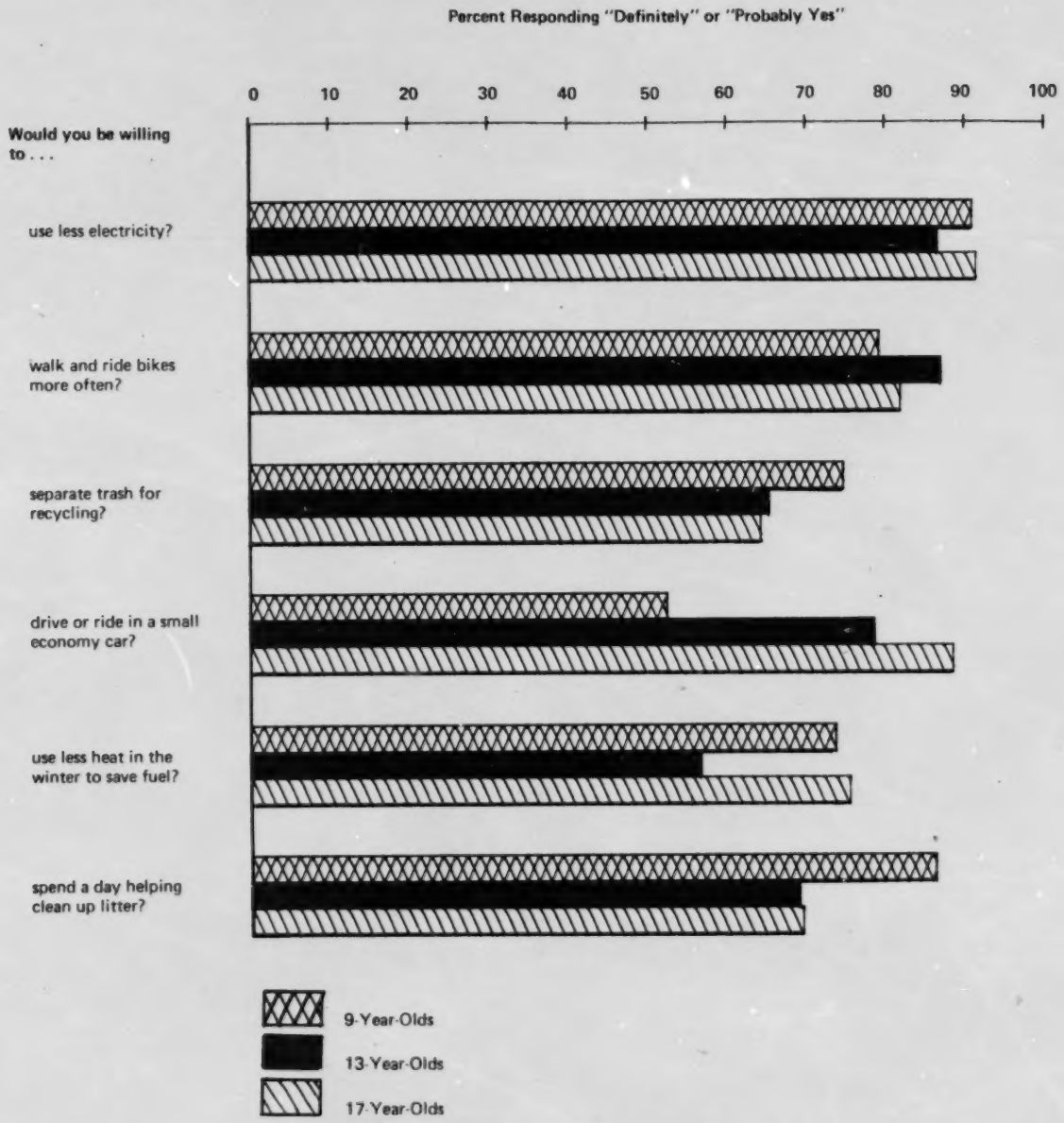
Less than one-fourth of either teenaged group always or often uses seat belts. In fact, 63% at age 13 and 65% at age 17 said that they seldom or never use them.

Summary of Group Results

Differences among groups on questions about personal involvement in science-related social problems were generally fairly small. In fact, for 13-year-olds, differences from the national level were negligible for all groups.

At age 9, males expressed slightly more involvement than females; however, by age 17, females were more likely than males to be involved in helping solve science-related societal problems. Fewer blacks than whites at ages 9 and 17 expressed involvement in such societal problems. In connection with activities they were willing to do to help solve these problems, teenaged blacks were farthest below the national level in willingness to use less heat in winter — both 13- and 17-year-olds were approximately 15 percentage points below the nation on this question.

EXHIBIT 15. Percentages Willing to Perform Various Conservation and Energy-Saving Activities, Ages 9, 13 and 17



Differences in type-of-community group performance varied with the ages of the students. Nine-year-olds living in advantaged-urban communities generally expressed more personal involvement than the nation, and those from disadvantaged-urban communities expressed less. Seventeen-year-olds from extreme-rural and disadvantaged-urban areas were approximately 3 percentage points below the nation, while the 17-year-old advantaged-urban group performed at the national level.

CHAPTER 3

AWARENESS OF THE METHODS, ASSUMPTIONS AND VALUES OF SCIENCE

Knowledge about the process of science — how science and scientists work — can be an important factor in one's attitudes toward science. If people think of science as a rigid, never-changing set of rules and formulas, they may be unaware of the possibility of making new discoveries by using scientific procedures.

Items included in this section assess understanding of the empirical nature of science, the usefulness of scientific theories and the necessity for self-criticism by scientists. Some of the items in this section were administered to adults as well as to 17-year-olds; none were given to 9-year-olds. Two sets of questions for 17-year-olds were also administered in 1972—73, providing data on changes in performance for those items.

Seventeen-year-olds appeared more aware than 13-year-olds of the nature and methods of science. On the average, about two-thirds of the 13-year-olds and nearly four-fifths of the 17-year-olds responded to those questions in a manner indicating awareness of the assumptions and methods of the scientific process. On items administered to both 17-year-olds and adults, results for adults were generally either similar to or slightly above those for 17-year-olds.

One series of questions dealt with the empirical nature of science. Awareness of the nature of the scientific process seemed relatively high, as shown in Exhibit 16. People were least sure about whether scientists believe that all events have causes.

Another series of questions examined opinions about the way scientists work. Percentages indicating awareness of how scientists work were fairly high for 17-year-olds and adults (averages of 78% and 84%, respectively); percentages for 13-year-olds were somewhat lower (an average of 64%). As seen in Exhibit 17, most people agreed that scientists must make careful observations and be willing to change their ideas. But people were not as certain whether scientists should criticize each other's work.

Thirteen- and 17-year-olds also responded to questions about scientific theories. Most teenagers (81% of the 13-year-olds and 86% of the 17-year-olds) agreed that scientific theories are important products of science. Sixty-nine percent of the 13-year-olds and 80% of the 17-year-olds recognized that theories used today may be shown to be inadequate some day. However, teenagers seemed less sure of a potential use of scientific theories. Fifty-nine percent of the 13-year-olds and 62% of the 17-year-olds agreed that an important use of scientific theories is to predict future events. Nearly 20% at each age had no opinion on this question; an additional 21% at age 13 and 19% at age 17 disagreed.

Seventeen-year-olds responded to two series of questions that also had been assessed in 1972—73. Slightly fewer 17-year-olds in 1977 than in 1973 showed awareness of the nature of science, as measured by the questions shown on page 44.

Many students did not seem aware of the self-correcting nature of science. Eleven percent fewer students in 1977 than in 1973 disagreed with the idea that scientific laws are not subject to change.

EXHIBIT 16. Percentages of 13-Year-Olds, 17-Year-Olds and Young Adults Expressing Awareness of Various Aspects of the Scientific Endeavor

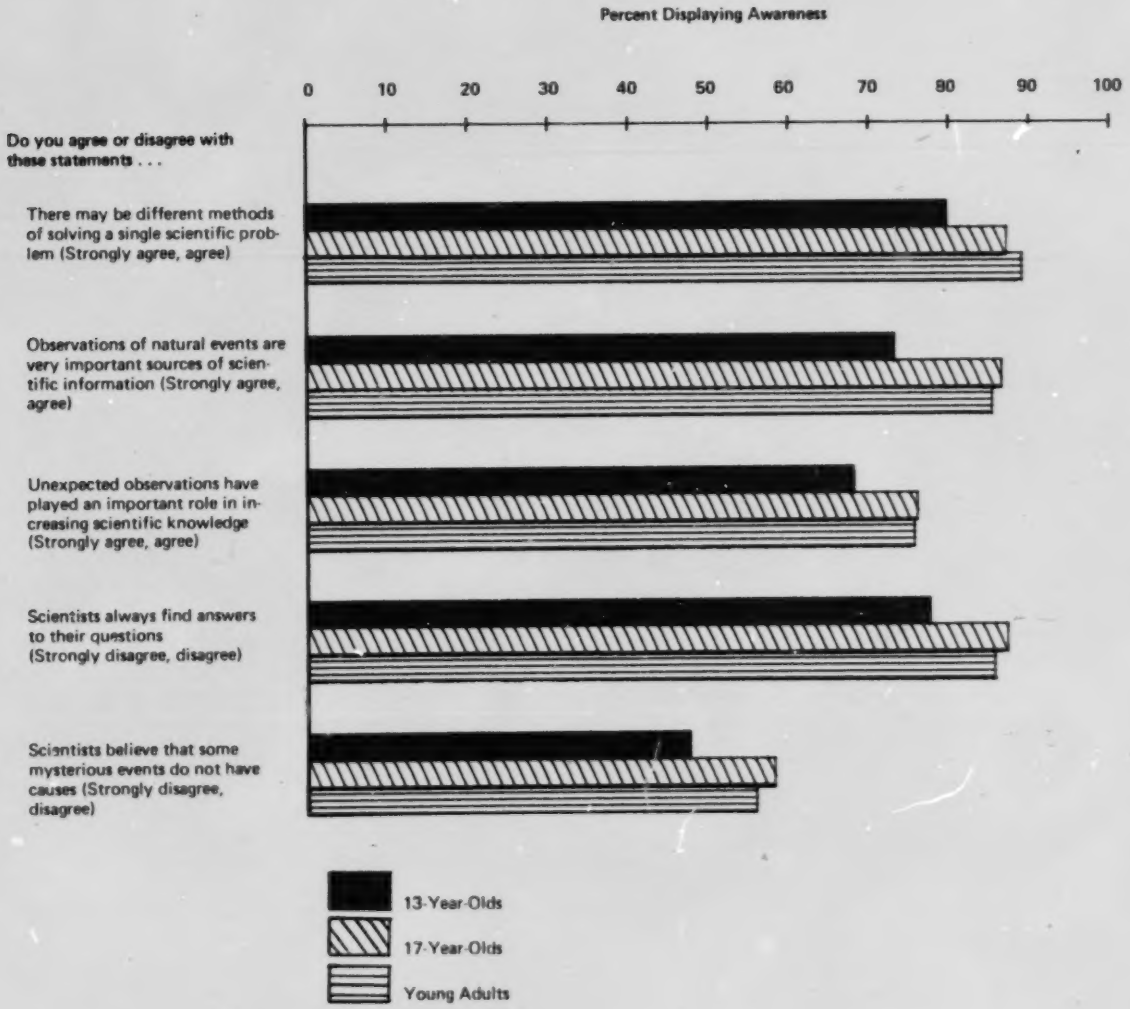
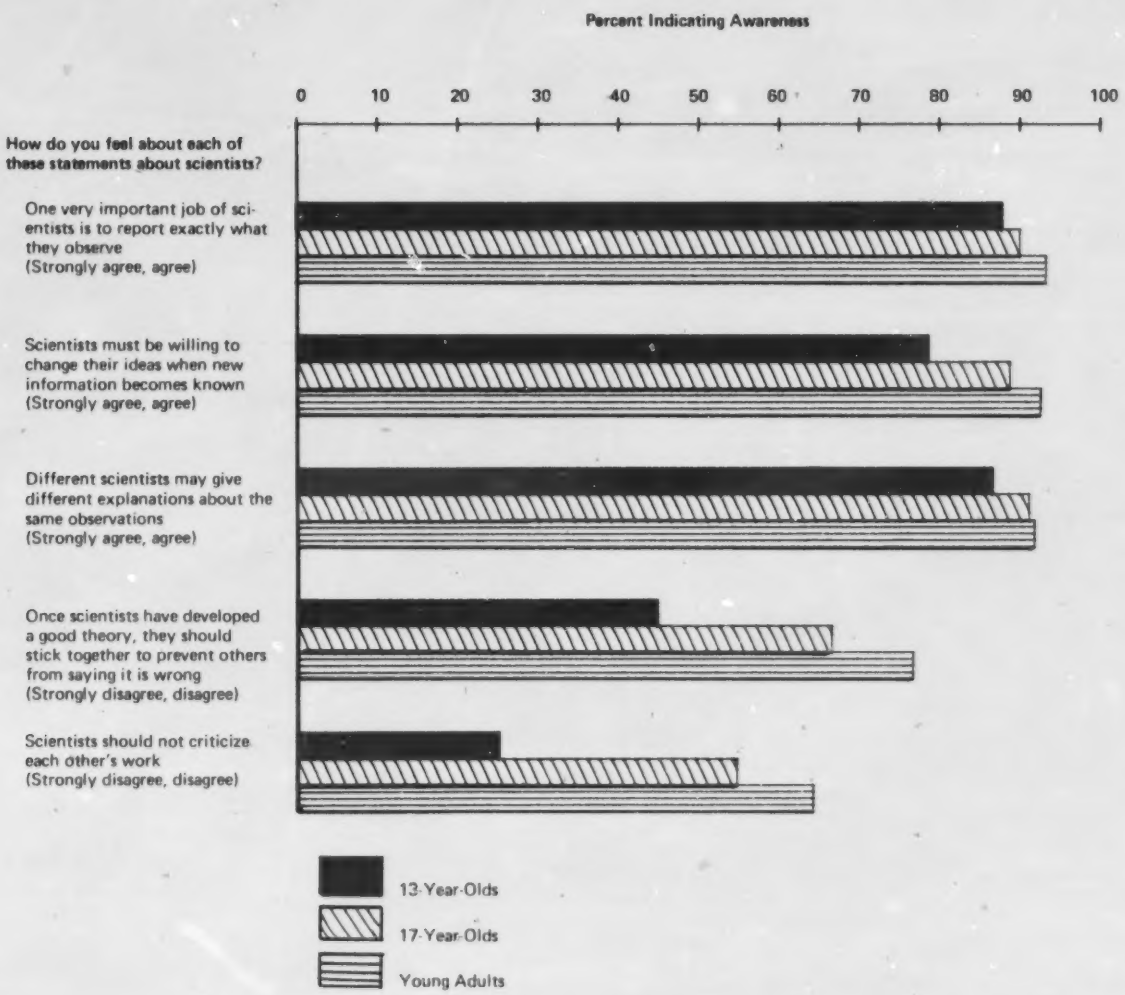

Percent Displaying Awareness
0
10
20
30
40
50
60
70
80
90
100
Do you agree or disagree with these statements . . .
There may be different methods of solving a single scientific problem (Strongly agree, agree)
Observations of natural events are very important sources of scientific information (Strongly agree, agree)
Unexpected observations have played an important role in increasing scientific knowledge (Strongly agree, agree)
Scientists always find answers to their questions (Strongly disagree, disagree)
Scientists believe that some mysterious events do not have causes (Strongly disagree, disagree)
13-Year-Olds
17-Year-Olds
Young Adults

EXHIBIT 17. Percentages of 13-Year-Olds, 17-Year-Olds and Young Adults Indicating Awareness of How a Scientist Works


Percent Indicating Awareness
0
10
20
30
40
50
60
70
80
90
100
How do you feel about each of these statements about scientists?
One very important job of scientists is to report exactly what they observe (Strongly agree, agree)
Scientists must be willing to change their ideas when new information becomes known (Strongly agree, agree)
Different scientists may give different explanations about the same observations (Strongly agree, agree)
Once scientists have developed a good theory, they should stick together to prevent others from saying it is wrong (Strongly disagree, disagree)
Scientists should not criticize each other's work (Strongly disagree, disagree)
13-Year-Olds
17-Year-Olds
Young Adults

Following are a series of statements about the nature of science. For each statement, indicate whether you agree, whether you disagree, or whether you neither agree nor disagree with the statement.

	1972–73	1976–77
Scientists believe that the universe will be completely understood in a few years. Disagree	79%	76%
Science is a self-correcting enterprise. Agree	43	37
Scientific conclusions are statements that something is highly probable. Agree	73	68
Laws in science are statements which are not subject to change. Disagree	64	53
Theories in science never go beyond the observed facts on which they are based. Disagree	77%	81%
The usefulness of a theory is in its application in explaining natural events. Agree	75	76
Theories exist in the forms of words, mechanical models and mathematical models. Agree	75	75
The more complicated the theory, the better satisfied the scientists will be with it. Disagree	72	70

Seventeen-year-olds' awareness of scientific theories and the roles of these theories in science did not appear to change very much between 1973 and 1977. In both years, the average on seven questions was very close to 75%. Average percentages for some of these questions are shown in the next table.

About three-quarters of the 17-year-olds in each assessment realized that the usefulness of a theory is in its application in explaining natural events. Slightly higher percentages knew that scientific theories can go beyond the observed facts on which they are based. Around 70% disagreed with the statement that the more complicated the theory, the more satisfied the scientist will be with it.

Summary of Group Results

Regional differences on these items were virtually nonexistent for all age groups; sex differences were negligible for 13- and 17-year-olds. Those whose parents had lower levels of education showed less awareness about the scientific process than those whose parents had higher education levels. Grade level also appeared related to scientific awareness, with those in the higher grades for their ages showing greater awareness.

Teenaged blacks and residents of disadvantaged-urban areas were farther below the nation on this set of items than on nearly all of the previous sections, with the exception of the science-related experience questions. Blacks and whites were separated by 8 to 11 percentage points, on the average; disadvantaged-urban students performed from 6 to 8 percentage points below the nation. At both ages 13 and 17, extreme-rural students responded similarly to the nation as a whole; advantaged-urban students at age 13 were above the national level in awareness about science.

Young adult males displayed somewhat higher levels of awareness than females. There was a 23-percentage-point discrepancy between blacks' and whites' performance — an average of 62% of the blacks and 85% of the whites displayed awareness of scientific

methods on these questions. Adults' own levels of education also seemed to be related to scientific awareness. Sixty-two percent of those who had not graduated from high school, 79% of the high school graduates and 89% of those with some education beyond high school, on the average, demonstrated awareness of scientific methods and philosophies. Those who had scientific training or science-related jobs displayed higher awareness levels than those who did not.

CHAPTER 4

A COMPARISON OF RESULTS ON ATTITUDINAL AND COGNITIVE SCIENCE ITEMS

In addition to the attitudinal items discussed in this report, National Assessment conducted an extensive survey of 9-, 13- and 17-year-olds' achievement on cognitive science items (*Science Achievement in the Schools*, 1978). Cognitive items were classified both by taxonomic level and by science content area. Four taxonomic levels were defined: (1) knowledge; (2) comprehension; (3) application; and (4) analysis, synthesis and evaluation. Content was classified under three topics: (1) the body of knowledge of science, (2) the process of science and (3) the implications of science for society.

Results for the cognitive items in some cases followed patterns different from those observed for the attitudinal items. Variations were seen in performances of the different reporting groups and in results for the different age levels.

Results on cognitive items for 9-, 13- and 17-year-olds were reported for the nation and for the population subgroups described in the Introduction. Tables 7, 8 and 9 display differences from the national performance level for each reporting group, by age. Positive numbers indicate that a group's percentage was above that of the nation; negative numbers mean a group performed below the national level.

As reported by National Assessment, "the performance levels of most reporting groups were highly consistent across the three age levels assessed .... [G]roups that tend to perform above or below the national average at one age tend to do so at other ages as well" (*Science Achievement in the Schools*, 1978, p. 19). Results also showed that "the relative performance of each group tended to be consistent across all content areas and taxonomic levels described in the science assessment" (*Science Achievement in the Schools*, 1978, p. 32).

The following patterns were found on the cognitive items:

- The Southeast achieved consistently below the national level and the Northeastern and Central regions achieved typically above it.
- Performance of males was typically above that for females, especially in knowledge of content areas and the taxomonic classifications. However, this was not always the case in the science-and-self and decision-making areas.
- At all ages, there were large disparities in the achievement of blacks and whites. Performance of blacks ranged from 10 to 20 percentage points below the national average.
- Parental-education groups followed a consistent pattern. Those whose parents had higher levels of education showed higher achievement levels than those whose parents had less formal education.
- Students living in disadvantaged-urban communities were substantially below the national level, while those living in advantaged-urban communities performed considerably above the nation. Extreme-rural students generally were at the national level.

TABLE 7. Relative Group Differences From the Nation by Taxonomic Level and Content Area of Science, Age 9

		Taxonomy				Content								
	All Items	Knowledge	Comprehension	Application	Analysis and Synthesis	Biology	Physical Science	Earth Science	Integrated Topics	Process Methods	Persistent Societal Problems	Science and Self	Applied Science and Technology	Decision Making
Number of items	209	26	119	51	10	66	71	27	2	41	12	14	1	1
Region														
Southeast	-4.2*	-4.0*	-4.3*	-3.3*	-7.5*	-4.0*	-3.5*	-3.4*	---	-5.9*	-2.3	-3.8*	---	---
Central	1.3	0.5	1.5	1.3	2.6*	1.5	0.9	1.0	---	2.1*	1.4	1.2	---	---
West	0.3	1.3	0.4	-0.4	-0.3	0.6	0.7	0.5	---	-0.7	-0.2	0.9	---	---
Northeast	1.6*	1.4	1.5*	1.6*	3.3*	0.9	1.3*	1.2	---	3.2*	0.5	0.9	---	---
Sex														
Male	1.5*	2.2*	1.8*	1.0*	0.1	1.1*	2.5*	2.5*	---	0.6*	-0.2	0.5	---	---
Female	-1.6*	-2.2*	-1.8*	-1.1*	-0.1	-1.2*	-2.6*	-2.6*	---	-0.6*	0.2	-0.5	---	---
Race														
White	2.5*	2.3*	2.4*	2.5*	3.3*	2.5*	2.0*	1.9*	---	3.4*	2.2*	2.6*	---	---
Black	-12.9*	-12.9*	-12.5*	-12.8*	-17.0*	-13.0*	-10.8*	-11.2*	---	-17.1*	-10.9*	-13.1*	---	---
Hispanic	-8.5*	-5.9*	-8.5*	-8.4*	-13.6*	-7.9*	-7.0*	-4.9*	---	-12.9*	-10.6*	-9.5*	---	---
Parental education														
Not graduated high school	-6.4*	-6.2*	-6.5*	-5.8*	-7.9*	-6.5*	-4.8*	-6.5*	---	-9.1*	-4.9*	-4.1*	---	---
Graduated high school	1.7*	1.7*	1.8*	1.2*	2.0*	1.6*	1.5*	2.2*	---	1.6*	1.8*	1.9*	---	---
Post high school	5.1*	4.8*	5.2*	5.0*	5.0*	5.1*	4.2*	5.2*	---	6.2*	5.3*	4.9*	---	---
Type of community														
Extreme rural	1.4	2.1	1.4	-0.9	1.6	1.6	0.7	1.5	---	1.8	1.1	0.9	---	---
Low metro	-11.7*	-11.3*	-11.5*	-11.4*	-16.0*	-11.7*	-8.9*	-10.3*	---	-15.9*	-11.9*	-12.7*	---	---
High metro	7.6*	6.0*	8.0*	6.7*	11.7*	6.5*	6.5*	6.8*	---	10.9*	7.1*	6.6*	---	---
Size of community														
Big cities	-4.7*	-3.6*	-4.6*	-4.9*	-5.9*	-4.6*	-3.7*	-4.3*	---	-6.4*	-4.4*	-3.9*	---	---
Fringes around big cities	4.3*	3.7*	4.6*	3.4*	6.1*	4.0*	3.5*	4.8*	---	5.6*	4.2*	4.4*	---	---
Medium cities	-1.0	-1.0	-1.0	-1.1	-1.2	-1.5	-0.7	-0.4	---	-1.0	-0.4	-1.7	---	---
Smaller places	0.3	0.0	0.1	0.7	0.1	0.5	0.1	-0.3	---	0.3	0.1	0.0	---	---
Grade														
3	-7.2*	-7.4*	-7.1*	-7.1*	-8.9*	-6.8*	-6.2*	-6.5*	---	-9.7*	-7.9*	-7.0*	---	---
4	2.4*	2.4*	2.4*	2.4*	3.1*	2.3*	2.1*	2.2*	---	3.2*	2.6*	2.4*	---	---

**Indicates mean percentages significantly different from the nation at the .05 level.*

TABLE 8. Relative Group Differences From the Nation by Taxonomic Level and Content Area of Science, Age 13

		Taxonomy				Content								
	All Items	Knowledge	Comprehension	Application	Analysis and Synthesis	Biology	Physical Science	Earth Science	Integrated Topics	Process Methods	Persistent Societal Problems	Science and Self	Applied Science and Technology	Decision Making
Number of items	284	29	139	68	28	77	66	43	14	58	48	22	15	11
Region														
Southeast	-3.0*	-2.5*	-2.3*	-3.9*	-4.6*	-2.4*	-3.2*	-3.2*	-3.5*	-4.1*	-1.9*	-3.8*	-2.2	-2.9*
Central	1.6*	0.6	1.3	2.2*	2.1*	1.3	1.9*	1.9*	1.5	2.5*	0.7	1.5*	-0.0	0.6
West	-1.5	-0.5	-1.6*	-1.7*	-0.9	-0.9	-1.7*	-1.6	-1.2	-2.4*	-1.2	-0.6	-1.1	-1.6
Northeast	2.1*	1.9*	2.0*	2.4*	2.0*	1.5*	2.1*	1.9*	2.5*	2.9*	1.8*	2.0*	2.5*	3.0*
Sex														
Male	1.8*	1.7*	2.0*	1.6*	0.9*	1.0*	3.7*	2.8*	0.9*	0.5*	1.9*	0.2	2.2*	-1.1*
Female	-1.7*	-1.7*	-2.0*	-1.6*	-0.8*	-1.0*	-3.7*	-2.8*	-0.9*	-0.5*	-1.9*	-0.3	-2.2*	1.1*
Race														
White	2.9*	2.7*	2.8*	3.2*	3.2*	2.8*	2.8*	2.8*	2.4*	3.4*	2.7*	3.2*	2.8*	3.3*
Black	-11.7*	-10.8*	-11.0*	-12.6*	-12.9*	-10.8*	-11.4*	-12.2*	-10.1*	-13.2*	-10.6*	-12.1*	-10.9*	-13.8*
Hispanic	-10.3*	-9.9*	-9.9*	-10.9*	-10.4*	-9.4*	-9.7*	-10.2*	-9.7*	-11.7*	-10.2*	-11.8*	-7.3*	-12.8*
Parental education														
Not graduated high school	-6.9*	-5.8*	-6.8*	-7.2*	-8.0*	-6.7*	-6.9*	-7.4*	-7.1*	-7.4*	-6.4*	-6.0*	-7.5*	-9.8*
Graduated high school	-0.9*	-1.1*	-0.9*	-0.6*	-1.2*	-1.0*	-0.4*	-0.9*	-1.3*	-0.6	-1.4*	-0.7*	-1.6*	-1.4*
Post high school	5.7*	5.2*	5.6*	5.7*	6.6*	5.6*	5.0*	5.6*	5.3*	6.3*	6.1*	5.1*	7.3*	7.4*
Type of community														
Extreme rural	-0.2	-0.4	-0.1	-0.4	0.3	-0.4	-0.5	0.8	-1.7	0.6	-0.1	-1.4	-2.8*	-0.9
Low metro	-11.1*	-10.5*	-10.7*	-11.1*	-13.4*	-10.7*	-10.0*	-11.0*	-9.2*	-13.4*	-10.2*	-10.3*	-10.9*	-12.5*
High metro	6.3*	4.3*	6.3*	7.0*	6.6*	5.6*	6.7*	7.3*	4.2*	6.8*	5.4*	4.6*	8.5*	7.2*
Size of community														
Big cities	-2.2*	-2.4*	-1.9	-2.6*	-2.2	-1.8	-2.3*	-1.9	-1.3	-2.4	-2.8*	-2.7*	-1.1	-1.7
Fringes around big cities	1.9	1.6	1.4	2.6*	2.1	2.0*	2.0	1.7	0.7	1.9	1.0	1.5	3.0*	1.8
Medium cities	0.6	1.7	0.3	0.8	0.7	1.0	0.2	0.0	1.8	0.7	1.3	2.0	-0.3	-0.2
Smaller places	0.0	-0.1	0.1	-0.1	-0.1	-0.3	0.1	0.0	-0.2	0.1	0.4	0.1	-0.8	0.2
Grade														
7	-6.4*	-6.1*	-6.1*	-6.7*	-7.4*	-6.4*	-5.5*	-5.5*	-6.0*	-7.9*	-6.2*	-5.8*	-6.8*	-8.3*
8	2.5*	2.3*	2.4*	2.6*	2.9*	2.4*	2.2*	2.2*	2.2*	3.1*	2.3*	2.3*	2.4*	3.2*

*Indicates mean percentages significantly different from the nation at the .05 level.

TABLE 9. Relative Group Differences From the Nation by Taxonomic Level and Content Area of Science, Age 17

		Taxonomy				Content								
	All Items	Knowledge	Comprehension	Application	Analysis and Synthesis	Biology	Physical Science	Earth Science	Integrated Topics	Process Methods	Persistent Societal Problems	Science and Self	Applied Science and Technology	Decision Making
Number of items	313	32	140	110	31	74	82	43	19	62	56	25	21	16
Region														
Southeast	-4.1*	-2.9*	-3.4*	-4.8*	-5.7*	-3.8*	-3.7*	-4.4*	-5.6*	-5.6*	-3.7*	-2.8*	-4.4*	-2.9*
Central	1.2*	0.4	1.1	1.5*	1.7*	0.8	0.9	1.2*	2.0*	2.0*	1.7*	1.1*	1.6	1.7*
West	-0.8	-0.9	-0.8	-0.9	-0.5	-0.8	-1.0	-0.1	-0.2	-1.1	-0.6	-1.0	-0.5	-1.4
Northeast	2.2*	2.5*	1.8*	2.5*	2.5*	2.5*	2.6*	1.8*	1.7	2.7*	0.9	1.5*	1.7	1.3
Sex														
Male	2.6*	2.7*	2.9*	2.5*	1.7*	1.7*	4.7*	3.6*	2.2*	1.6*	2.6*	-0.2	3.2*	-1.2*
Female	-2.5*	-2.6*	-2.8*	-2.5*	-1.7*	-1.7*	-4.5*	-3.5*	-2.1*	-1.5*	-2.5*	0.2	-3.1*	1.2*
Race														
White	2.6*	2.2*	2.4*	2.8*	3.3*	2.4*	2.3*	2.6*	2.7*	3.2*	2.9*	2.3*	2.7*	2.8*
Black	-15.7*	-13.4*	-14.4*	-17.0*	-19.6*	-14.5*	-13.9*	-15.9*	-16.7*	-19.1*	-17.2*	-13.4*	-15.9*	-16.9*
Hispanic	-10.8*	-9.5*	-10.2*	-11.5*	-12.3*	-9.4*	-9.1*	-9.6*	-10.5*	-14.2*	-12.3*	-10.5*	-11.0*	-12.4*
Parental education														
Not graduated high school	-8.0*	-7.4*	-7.3*	-8.7*	-9.4*	-7.6*	-7.8*	-7.2*	-8.7*	-9.9*	-7.8*	-5.9*	-8.0*	-8.3*
Graduated high school	-1.8*	-1.7*	-1.8*	-1.7*	-1.9*	-1.7*	-1.9*	-2.1*	-2.0*	-1.7*	-1.5*	-1.1*	-2.3*	-1.7*
Post high school	5.1*	4.6*	4.9*	5.3*	5.7*	4.8*	5.0*	4.9*	5.5*	5.8*	4.9*	3.8*	5.4*	5.3*
Type of community														
Extreme rural	0.0	0.8	0.0	-0.1	-0.4	-0.3	-0.6	0.1	-1.3	-0.1	1.2	1.5	1.4	0.0
Low metro	-12.3*	-11.8*	-11.3*	-13.0*	-14.7*	-10.7*	-10.3*	-12.7*	-13.9*	-15.4*	-13.7*	-12.8*	-10.4*	-14.3*
High metro	4.4*	4.6*	4.4*	4.2*	5.5*	4.7*	4.4*	3.3	5.5*	5.6*	4.0*	3.7*	3.6	5.2*
Size of community														
Big cities	-5.8*	-5.1*	-5.4*	-6.2*	-6.8*	-5.0*	-4.9*	-6.4*	-6.5*	-6.4*	-7.3*	-4.9*	-6.6*	-6.5*
Fringes around big cities	2.8*	2.5*	2.6*	3.2*	3.2*	2.9*	2.5*	2.6*	4.1*	3.3*	2.8*	2.2*	2.8*	3.2*
Medium cities	1.7	0.9	1.5	1.8	3.1	1.7	1.4	1.4	2.7	2.6	1.5	0.7	3.3	0.7
Smaller places	0.5	0.6	0.5	0.4	0.4	0.2	0.3	1.0	-0.2	0.2	1.2	0.9*	0.6	0.6
Grade														
10	-10.2*	-8.4*	-9.2*	-11.1*	-13.1*	-9.5*	-8.6*	-8.7*	-11.9*	-14.0*	-10.2*	-8.8*	-10.1*	-12.7*
11	1.6*	1.2*	1.5*	1.8*	1.9*	1.5*	1.4*	1.4*	2.0*	2.1*	1.7*	1.4*	1.7*	1.9*
12	3.3*	3.2*	2.7*	3.7*	4.7*	3.2*	2.4*	2.2*	3.6*	5.2*	2.5*	3.2*	2.4*	5.0*

*Indicates mean percentage significantly different from the nation at the .05 level.

- Those living in big cities were usually below the nation; those living in the fringes around big cities generally performed above the nation. Performance of other community-size groups was similar to that of the nation.

- Fairly large differences were seen among children in different grade levels. Those in the lower grades for their age levels did not do as well as those in higher grades.

Tables 10, 11, 12 and 13 display group differences from national performance on different categories of attitudinal items for 9-, 13- and 17-year-olds and young adults. On the whole, differences were smaller than for the cognitive items, and patterns of response were not as consistent.

Regional differences were slight. At ages 13 and 17, the Southeast was slightly below the national level in experiences, but above the nation in expressing favorable attitudes toward scientific vocational or educational aspirations. Seventeen-year-olds in the Southeast were also above the nation in favorable attitudes toward science classes.

The distinct male advantage on cognitive items was not as pervasive on the attitudinal questions. Nine-year-old males reported more science-related experiences and more personal involvement with science-related problems than females; percentages of males and females at this age who had favorable attitudes toward science classes, and who used the tools and attributes of science, were about the same. At age 13, males showed more favorable attitudes toward science classes and science as a career, more science-related experiences and more use of the tools and attributes of science than females, but differences on questions about science and society and about awareness of the scientific process were negligible. Similar trends were seen for 17-year-old males and females, except that females were slightly more likely than males to be involved in solving science-related societal problems. In contrast, adult males were more supportive of research and more aware of the scientific process than females.

Patterns for blacks differed from those seen on cognitive items, and differences generally were not as large. Nine-year-old blacks and whites expressed similar feelings about science classes and toward using the tools of science. However, blacks at this age were less likely than their white counterparts to have or want to have experiences with science or to be personally involved with science-related societal problems.

More 13- and 17-year-old blacks than whites expressed positive feelings toward science as a career, and many more 17-year-old blacks than whites expressed positive feelings about science classes. Teenaged blacks were at or slightly below national levels in support for research, involvement in problem-solving and use of scientific tools. However, blacks at these ages were farther below whites in science-related experiences and awareness of the scientific process. Differences in these areas became larger from age 13 to age 17, and differences for black and white adults appeared larger than those for 17-year-olds.

Patterns of performance for students from disadvantaged-urban areas were similar to those seen for blacks. More 17-year-olds from these areas expressed more favorable attitudes toward science classes than did the nation. Both 13- and 17-year-olds from these areas appeared to have more favorable attitudes toward science as a career but fewer science-related experiences and less awareness of the scientific process than the entire country. However, their performance on cognitive items was in all cases below that of the nation. Extreme-rural 9- and 13-year-olds had attitudes similar to those of the nation, but at age 17, extreme-rural students were below national levels in a number of areas.

Patterns on attitudinal items were generally similar to those on cognitive items for the three parental-education groups. Those whose parents had lower levels of formal education

TABLE 10. Group Differences From the Nation for Various Types of Attitudinal Items, Age 9

			Personal Experiences		
	Science Classes (16)†	Tools and Attributes (8)	Personal Involvement (16)	Experiences Had (45)	Experiences Like To Have (45)
National	69.5%	60.1%	74.2%	55.5%	73.0%
Region					
Northeast	0.8	-0.8	1.5	0.2	1.3
Southeast	0.4	1.1	-0.4	-2.7*	-2.7
Central	-0.4	-1.0	0.4	1.0	1.0*
West	-0.6	1.0	-1.7	0.9	-0.1
Sex					
Male	0.6	-0.2	1.3*	2.7*	1.0*
Female	-0.6	0.3	-1.4*	-2.7*	-1.0*
Race					
White	0.1	-0.1	1.4*	1.0*	1.8*
Black	-1.0	0.9	-6.7*	-4.4*	-7.3*
Parental education					
Not graduated high school	0.2	-1.4	-1.6	-2.2*	-4.0*
Graduated high school	1.9*	0.9	2.2*	1.1*	1.1*
Post high school	2.2*	1.4*	2.9*	4.0*	3.6*
Type of community					
Extreme rural	0.7	1.8	0.9	0.4	1.3
Low metro	-1.5	-1.3	-7.2*	-3.9*	-7.9*
High metro	-0.7	3.7	4.8*	3.4*	3.7*
Size of community					
Big cities	1.1	-1.3	-3.5*	-1.3	-3.4*
Fringes around big cities	-1.6	1.8	2.6*	1.9*	1.7*
Medium cities	-2.2*	0.2	-0.2	-0.3	-0.8
Smaller places	0.8	-0.3	0.3	-0.1	0.9
Grade					
3	-1.7*	-0.9	-3.1*	-3.5*	-4.7*
4	0.6*	0.4	1.2*	1.2*	1.6*

†*Numbers in parentheses indicate the number of items administered.*
**Indicates significant difference from the nation at the .05 level.*

TABLE 11. Group Differences From the Nation for Various Types of Attitudinal Items, Age 13

	Personal Experiences				Science and Society		Awareness (16)
	Science Classes (39)†	Vocational Aspirations (23)	Tools and Attributes (35)	All Experiences (90)	Support Research (35)	Personal Involvement (24)	
Nation	49.6%	51.9%	64.5%	59.9%	72.1%	53.1%	67.6%
Region							
Northeast	-0.7	-2.0	1.6*	-0.7	0.2	-0.7	2.6*
Southeast	2.0	5.1*	-3.1*	1.1	0.6	1.0	-0.3
Central	0.0	-1.5	1.4*	0.0	-0.3	-0.5	-0.2
West	-0.9	-0.3	-0.6	-0.2	-0.4	0.6	-2.7
Sex							
Male	1.8*	2.6*	2.3*	1.4*	0.3	-0.6	-0.2
Female	-1.8*	-2.6*	-2.2*	-1.5*	-0.3	0.6*	0.2
Race							
White	-0.2	-1.0*	1.6*	0.4*	0.7*	0.3	1.9*
Black	0.6	5.0*	-6.1*	-2.6*	-2.9*	-2.0	-6.4*
Parental education							
Not graduated high school	-1.0	-2.4*	-5.2*	-3.1*	-2.9*	-1.3	-4.5*
Graduated high school	0.3	-0.2	-0.9*	-1.8*	-0.4	-0.1	0.0
Post high school	0.9*	2.0*	4.2*	3.6*	2.1*	1.3*	5.1*
Type of community							
Extreme rural	0.5	-0.8	-1.6*	-2.3	-1.6	-0.5	0.6
Low metro	2.3	4.4*	-6.9*	-1.1	-2.3	0.4	-6.4*
High metro	-4.4*	-7.5*	5.7*	3.4*	3.9*	2.5	5.5*
Size of community							
Big cities	0.1	2.9	-0.8	2.2*	-1.1	-1.8	-1.2
Fringes around big cities	-1.3	-2.8	1.4	0.1	1.9*	-0.2	-1.2
Medium cities	1.1	0.8	-0.0	1.3	-0.1	-0.1	2.0
Smaller places	0.3	-0.6	-0.2	-1.3*	-0.2	0.9*	0.3
Grade							
7	0.8	0.3	-3.0*	-1.1	-1.7*	-0.9	-6.1*
8	-0.3	-0.2	1.2*	0.7*	0.8*	0.1	2.5*

†*Numbers in parentheses indicate the number of items administered.*
**Indicates significant differences from the nation at the .05 level.*

TABLE 12. Group Differences From the Nation for Various Types of Attitudinal Items, Age 17

	Personal Experiences				Science and Society		Awareness (16)
	Science Classes (39)†	Vocational Aspirations (23)	All Experiences (90)	Tools and Attributes (35)	Support Research (35)	Personal Involvement (24)	
Nation	45.7%	48.5%	72.4%	61.4%	77.9%	56.5%	78.1%
Region							
Northeast	-1.0	-0.9	0.7	1.3*	0.8	-0.2	1.7
Southeast	2.7*	3.2*	-2.5*	0.9*	-1.2	0.3	-0.2
Central	-0.2	-1.9*	1.2*	-1.4*	0.1	-0.7	-0.1
West	0.7	1.2	-0.4	1.3	0.1	0.9	-1.2
Sex							
Male	2.1*	2.3*	2.7*	1.7*	0.2	-2.6*	-0.4
Female	-2.0*	-2.4*	-2.6*	-1.7*	-0.2	2.6*	0.4
Race							
White	-0.7*	-1.6*	1.7*	0.3	0.5*	0.5*	1.9*
Black	5.2*	9.1*	-9.7*	-1.7	-3.1*	-2.9*	-9.5*
Parental education							
Not graduated high school	-1.4	-1.4	-6.0*	-5.6*	-2.0*	-2.4*	-5.9*
Graduated high school	-1.4*	-4.3*	-1.2*	-2.1*	-1.4*	-1.5*	-1.7*
Post high school	1.8*	3.5*	3.6*	3.8*	2.2*	2.5*	4.2*
Type of community							
Extreme rural	-3.3*	-5.4*	-1.0	-3.7*	-1.5	-2.7*	-1.3
Low metro	7.2*	8.5*	-9.8*	-0.9	-1.6	-2.6*	-8.2*
High metro	0.1	1.5	1.9	2.4*	2.9*	-0.1	2.6
Size of community							
Big cities	3.9*	5.9*	-4.1*	0.3	-1.3	-0.5	-2.8*
Fringes around big cities	-0.4	-1.2	2.0*	0.4	-0.4	-0.9	2.7*
Medium cities	-0.3	-1.9	1.9	0.8	2.9*	1.5	0.5
Smaller places	-1.0	-1.3	0.2	-0.5	-0.0	0.3	-0.1
Grade							
10	0.4	-1.7	-4.4*	-5.0*	-3.2*	-3.2*	-9.3*
11	-0.2	-0.0	0.7*	0.4*	0.5*	0.0	1.2*
12	0.6	0.1	1.2*	3.7*	1.2	3.7*	2.9*

†*Numbers in parentheses indicate the number of items administered.*
**Indicates significant differences from the nation at the .05 level.*

TABLE 13. Group Differences From the Nation for Various Types of Attitudinal Items, Adults

	Research (35)†	Awareness (11)
Nation	82.5%	81.2%
Region		
Northeast	1.9	1.5
Southeast	-0.0	-1.6
Central	-0.8	2.9
West	-0.8	-3.7
Sex		
Male	2.9*	2.3*
Female	-2.5*	-2.0*
Race		
White	1.4*	4.0*
Black	-7.4*	-19.2*
Own education		
Not graduated high school	-8.0*	-19.1*
Graduated high school	-3.8*	-2.4*
Post high school	5.0*	8.0*
Science training		
Science training	4.8*	8.2*
No science training	-2.9*	-5.3*
Science-related job		
Science-related job	5.6*	8.8*
No science-related job	-1.0*	-1.8*

†*Numbers in parentheses indicate the number of items administered.*
**Indicates significant differences from the nation at the .05 level.*

generally held less favorable attitudes and had fewer experiences than those whose parents had higher levels of education. Differences were usually smaller than in the cognitive areas, however.

Differences for size-of-community groups were not as consistent or as marked for these attitudinal items as for cognitive categories.

Slight differences were evident in 9-year-olds' responses by grade level. Fourth graders had more experiences than third graders and claimed more personal involvement in solving science-related societal problems. For 13-year-olds, grade-level differences were most marked on questions about experiences and awareness of the scientific method. Seventeen-year-olds in all grades reported about the same extent of favorable attitudes toward science classes and toward science as a career. In other areas, students in higher grades reported more favorable attitudes and more experiences than those in lower grades.

Adult groups, especially blacks and those who have not graduated from high school, showed considerable divergence below the national level in the two areas for which their results were summarized.

Patterns of performance for the three in-school age groups on some areas of the science attitudes assessment differed strikingly from performance on the cognitive items. Comparisons were made on sets of identical items. On the cognitive items, 9- and 13-year-olds responded to 66 identical items and 13- and 17-year-olds answered 197 identical questions. Thirteen- and 17-year-olds responded to identical sets of attitudinal items. Although attitudinal questions for 9-year-olds were not identical with the older groups', they were similar enough to allow rough comparisons.

Performance on the cognitive items improved dramatically with age. Thirteen-year-olds had a 21-percentage-point average advantage over 9-year-olds, and 17-year-olds held a 14-percentage-point advantage over 13-year-olds (*Science Achievement in the Schools*, 1978, p. 31).

However, attitudes did not necessarily improve with age. The percentage expressing favorable attitudes toward science classes dropped from age 9 to 13 to 17. Thirteen-year-olds were also somewhat more likely than 17-year-olds to favor scientific education and careers. Similarly, personal involvement in helping solve science-related societal problems was highest for 9-year-olds and dropped off for the teenaged groups; 17-year-olds displayed slightly more involvement than 13-year-olds.

In other areas, increases did occur with age. Support for research increased by about 6 percentage points between ages 13 and 17 and about 5 percentage points between ages 17 and 26—35. Experiences with science-related activities went up from ages 9 to 13 to 17. More 17- than 13-year-olds demonstrated awareness of the methods and philosophy of science.

Results on questions about scientific experiences and awareness of the scientific process followed patterns most like those for cognitive items, both in terms of group differences and age differences. It is important to note that neither of these areas focused strictly on attitudes. Awareness of scientific-process items had a strong cognitive component, and experience items, of course, inquired about actual happenings rather than feelings or opinions. Responses in both of these areas may be affected by factors similar to those influencing cognitive achievement.

When differences existed on more strictly attitudinal items, they were generally smaller than those found for cognitive topics. In several areas, patterns usually observed in cognitive areas were reversed. The younger ages were more likely than the older groups to be favorably inclined toward science classes and science as a career. Nine-year-olds showed more involvement in societal problems related to science than teenagers. Groups that are traditionally considered disadvantaged and

that usually do less well than other groups on cognitive items — blacks, those living in disadvantaged-urban areas, those living in the Southeast — showed more favorable attitudes toward science classes and science as a career than other groups traditionally viewed as more advantaged.

The assessment of science attitudes describes current attitudes, experience levels and beliefs. Future assessments will discover any changes in these areas and will provide, perhaps, additional information on the relationship of cognitive performance and attitudinal stance.

CHAPTER 5

IMPLICATIONS AND PERSPECTIVES

To help put the data on attitudes toward science into perspective, National Assessment asked several persons active in the field of science education to comment on the survey results and to consider the implications of these results for science education. Contributors were all members of Project Synthesis, a two-year project funded by the National Science Foundation (NSF) to develop an interpretive consolidation of the literature in science education in order to identify needs in precollege science education.

NINE-YEAR-OLDS' ATTITUDES TOWARD SCIENCE: An Interpretation of the National Assessment Data

Roger T. Johnson
University of Minnesota

Roger T. Johnson is associate professor of Science Education, University of Minnesota. He has served as curriculum developer and writer for the Elementary Science Study Program in Boston and has taught at the elementary level.

In 1956, a nationwide poll was conducted by the Purdue Opinion Panel to assess the attitudes of high school students toward science and scientists. Among other things, they found:

- Thirty percent of the students stated that you cannot expect to raise a normal family if you become a scientist.
- Twenty-seven percent felt that scientists are willing to sacrifice the welfare of others to further their own interests.
- Twenty-five percent believed that you have to be a genius to be a good scientist.
- Twenty-five percent perceived scientists as "more than a little bit odd."
- Twenty-eight percent believed that if you are a scientist, you don't have time to enjoy life.

The beliefs professed by these substantial percentages of high school students were alarming to the science community at that time. At about the same time as the poll, the Russians launched the Sputnik satellite into space and the alarm became something closer to panic. A considerable amount of resources were generated, primarily through the National Science Foundation (NSF), to improve the teaching of science so that, among other things, American youth would have realistic and positive attitudes about science and an openness to choosing science-related careers. But, how successful have we been in improving the attitudes of students toward science?

This section looks at the results of the attitudes questions that were part of the 1976–77 assessment of science, conducted by the National Assessment of Educational Progress (NAEP), and in particular at the responses of 9-year-olds. Results for *cognitive achievement* in science have been previously examined and discussed (*Science Achievement in the Schools*, 1978) and form an interesting background for discussion of the attitudinal data. It has proven to be important to measure the science achievement of students, but it is equally vital to know more about the attitudes that help to shape that achievement; that determine whether students will want to take nonrequired science courses; and that encourage or discourage students from going into science-related careers. In many ways, data from the attitudes part of the science assessment may be more informative than achievement data.

Definition and Relevance

In discussing attitudes, the first question one usually has to deal with is: "What are attitudes?" This is closely followed by a second, more pragmatic question: "So what?" An answer to the first question is that an attitude is a *predisposition, or state of readiness, to act in a particular way* (McDonald, 1959). Attitudes toward science show an evaluative, personal reaction to science as a subject matter. The set of attitudes a student has toward science act as a selective factor in determining what will be perceived, learned and believed. Some basic characteristics of attitudes are:

- They are directional orientations to science, showing basic acceptance or rejection.
- There is an intensity factor, so that students who feel negative about science can have a range of feeling from "strongly against" to just "slightly turned off."
- These attitudes are acquired, not inherited.
- Even though attitudes are generally characterized by stability and consistency, they can be changed.
- They have definite effects on cognitive learning, and certainly on career choices.

The answer, then, to the "So what?" question is that each student's science attitude will determine how he or she perceives science as a subject, his or her willingness to go beyond a minimum effort in class and to take other science classes, his or her willingness to consider a science-related career, and his or her desire to apply science-related practices outside of the structured science classroom setting.

It is also important to emphasize that the attitudes toward science found by National Assessment have many roots, but are largely determined by the science instruction these students are receiving. A second major source of student attitudes are the attitudes held by students' parents, and since it is conceivable that many of the parents were themselves students when the 1956 Purdue Opinion Poll was taken, we can infer that many of the parents held negative or inappropriate attitudes toward science and scientists (Purdue Opinion Panel, 1957).

Since the attitudes results have been well described by National Assessment, this section will examine parts of the data that are especially interesting or reflect an inconsistency of response. Although this section emphasizes data for 9-year-olds, some data for 13-year-olds are also included to show contrasts and possible trends and to describe experiences or attitudes more representative of students at the end of elementary school. The following questions are considered:

- What is the general attitude of 9-year-old students toward science as a subject?

- Do the attitudinal data reflect equal access to science by boys and girls? By minority and white students?
- What kinds of science classes are typical for 9-year-olds?
- What effect does the teacher have on students' attitudes?
- How important to 9-year-old students are environmental issues that are spotlighted today?
- What are the attitudes of 9-year-olds toward a science-related career?

Attitudes of 9-Year-Old Students Toward Science

At first glance, the data seem to indicate that 9-year-olds hold very positive feelings about science. Almost two-thirds of them stated that they were happy with science and over four-fifths said they were interested in science, but only about half said they felt excited or successful in science. Still, most of the attitudinal responses of the 9-year-olds were high. A look at how they ranked science in a list of favorite or least favorite subjects puts the data into perspective, however. Only 6% of the students ranked science as their favorite subject (while 48% listed math as favorite and another 24% listed English). It seems likely that the seemingly high positive responses of 9-year-olds are more an indication of how they feel about school in general than an indication of how they feel about science.

At any rate, the positive responses of the 9-year-olds were not shared by the 13-year-olds — one-third of them do not plan to take any more science than that which is required and another third are not sure they want to take any more. Less than half of the 13-year-old students claimed any interest in a science-related career. Further data comparing ages 13 and 17 indicate a general trend of decay in positive feelings about science. This downward trend of attitudes toward science was also shown in examining the results from the Minnesota School Affect Assessment, which showed attitudes steadily dropping from elementary school through high school. What is equally interesting is the drop in attitude scores from fall to spring at each grade level (Johnson and Johnson, 1976).

Equal Access to Science Instruction As Reflected in Attitudes

Another aspect of 9-year-olds' general attitudes toward science deserves a careful look. It would be desirable to have positive feelings toward science from all segments of the school population — girls as well as boys, minority as well as white students. There is some indication in the attitudes data that boys are already showing more positive feelings about science than girls at age 9 and that the differences in attitudes become more pronounced at ages 13 and 17. The difference between boys and girls was also evident in parts of the experiences-with-science data, especially concerning physical science. For example, 71% of the 13-year-old boys had at some time wired together an electrical circuit while only 34% of the girls had done so; 39% of the boys had made an electromagnet but only 14% of the girls had done so. There has traditionally been a drop off in girls' interest in science at about third grade and it appears that these data reflect that pattern. Considering the percentage of the population that is female, it appears that a major portion of female students, although attending the same science classes as males, begins to "turn off" as early as age 9.

There was little difference between the attitudes of white and black students at ages 9 and 13. However, by age 17, black students were more positive about science than white students. This is a trend in the opposite direction from the results of the achievement data, which indicated a consistent gap in science achievement between white and black students in favor of the white students.

Typical Science Classes for 9-Year-Olds: The Context

Science is not a high-priority subject at the elementary school level and is not seen as "basic" by most teachers. Even though 95% of the 9-year-olds reported that they study some science in school and elementary school teachers report between 19 and 35 minutes per day are spent in science (Weiss, 1978), there is reason to believe that elementary school students may go for long periods of time during their school years without any science being taught, or with science as an incidental afterthought (Stake, 1978). Science instruction is described as predominantly lecture/discussion with little "hands-on" activity, focused on a textbook, and predominantly "whole class" instruction with little use of small groups (Weiss, 1978). The NSF-funded programs (ESS, SCIS, SAPA, and MINNEMAST) are used in only a small percentage of classrooms; a majority of teachers say they have never seen these materials (Weiss, 1978).

In this context, then, 70% of the 9-year-olds said that the teacher makes science exciting. However, they also were consistent in their desire to take more field trips than they do, to increase their experience with rocks, electricity and personal health activities, to work with more instruments of various kinds and to do more experiments. As an example of the lack of experience expressed, only 58% of the 13-year-olds, having finished elementary school, had ever used a microscope to study things growing in water and only 39% of them had ever made a microscope slide. The basic picture of most of the science classes is that of discussing material from a textbook with the teacher (if any science is taught that day) — certainly not the kind of science teaching intended by the NSF-funded programs and evidently not the kind that would rank science as a "favorite" subject in the eyes of 9-year-olds.

One of the more interesting paradoxes in the data occurs in 9-year-olds' responses to questions about instruction. Ninety percent of them reported that their teachers asked questions and over two-thirds said that "the teacher likes for me to ask questions" and "give my ideas." Ninety-three percent agreed that *it feels good to find out something new on your own.* In contrast, almost two-thirds of the 9-year-olds said they would *rather be told an answer* than have to find the answer on their own, and 77% said they *didn't like questions they didn't know the answer to.* The students seem to be saying that questions are O.K. as long as they are questions they know the answers to; and, although it feels good to find out something new on their own, they would *rather* be told. This is not a bad description of what must happen in many of the "whole class" textbook discussions with the teacher, described earlier as a major mode of science teaching at this level. Such apparent ambivalence has to be rather alarming to those science educators interested in fostering inquiry and problem solving, and certainly it is not consistent with the intent of the NSF-sponsored curricula.

Teacher Effects on Attitudes

The most vital factors in a science classroom are the behavior of the teacher and the teacher's attitudes toward science. Many times people in science careers have pointed to one teacher who was the catalyst for their interest in science and in a science-related career. In the 1977 Center for Educational Research and Evaluation's Survey of Science Instruction, school district and State Department of Education personnel reported that major problems in elementary school science teaching are a lack of interest in science on the part of the teachers and inadequate preparation to teach science. The teachers themselves have reported insufficient knowledge and lack of inservice training as major barriers to their ability to teach science effectively (Helgeson et al., 1977).

Relative to these data, two-thirds of the 9-year-olds in the NAEP survey felt that their teachers knew a lot about science. However,

when they were asked if their teachers really liked science, 60% of the students replied, "I don't know." It appears that 9-year-olds perceive a lack of enthusiasm for science on the part of teachers, It is also interesting that the subjects selected as favorites by the 9-year-olds (English and mathematics) are those emphasized by most teachers at the elementary school level. The attitudes of teachers do affect the attitudes of students, and it is probable that science teaching in elementary schools will not improve until teachers are convinced that science, too, is basic to education. When teachers become more enthusiastic about teaching science, students might begin to see it as an important subject, maybe even a favorite.

Environmental Issues

There was high agreement among the 9-year-olds that issues like pollution, energy waste, disease and food shortages were serious problems, and they indicated a real willingness to help in some way. However, their responses also indicated that they had very little experience with environmental issues, very few environmentally related field trips, and very little experimentation in this area. Only a small percentage had ever visited an electricity generating plant or a sewage treatment plant. At age 13, very few students had ever used a pollution detection kit of some kind or had seen a solar heat collector, indicating that these were not part of their elementary school experiences. There was further indication in the achievement data that if environmental issues were discussed in class at all, the implications of related concepts, cause and effect, and other relationships were not understood by 9-year-olds.

The data suggest that 9-year-olds have a high interest in environmental issues, but that very little is being done in school to foster that interest except perhaps superficial discussion. Indications are that the same relationship appears to be true in the study of personal health and consumer education. Teachers are not capitalizing on students' positive attitudes and current interest in these topics in their science teaching.

Science-Related Career Interest

A major reason for encouraging and maintaining positive attitudes toward science is to promote the taking of further science courses beyond the required minimum and, in the long run, to open up opportunities for science-related careers. Examining student interest in a science career is an effective way to look at their attitudes toward science. In the NAEP data, 64% of the 9-year-olds felt that being a scientist would be fun, not a high percentage considering their positive response patterns on most questions. At age 9, 27% had already decided a science career would be too much work and another 20% felt it would be boring. Looking at the 13-year-olds: less than half felt that being a scientist would be fun, only half thought it would *not* be too much work (22% felt it would be too much work and another 28% were not sure); 42% felt it would *not* take too much education (30% felt it would and another 28% were not sure); and 26% felt it would be boring.

In other items about careers in science, 13-year-olds were asked to respond to a series of specific questions related to things scientists do. Less than half of the 13-year-olds expressed interest in working in a laboratory and less than one-third were interested in field studies; under 50% were interested in writing scientific reports and only 32% were interested in reading science articles. Less than half expressed interest in knowing anything more about science-related jobs.

At the same time, 81% of the 13-year-olds (one of the more positive responses in the data) expressed interest in seeing a scientist in action. It would seem that while students show relatively low interest in science in the schools at age 13, they are highly interested in watching a scientist doing the "real thing." In terms of a career choice, by age 13 many of the students are already convinced that

science is too hard, too much work, or would take too much education.

What are the attitudes of different segments of the population? Nine-year-old boys were slightly more positive about science than girls; white students at this age were slightly more enthusiastic than black students. The major variable relating to career interest seems to be education — students whose parents had a high school education or beyond were more enthusiastic than those students whose parents did not complete high school. However, looking at the older age group, we find that it is the *advantaged-urban* students at age 13 who are much *less* convinced of the benefits of a science career than the disadvantaged-urban. Why are these students turned off? Certainly a higher percentage of their parents have had high school and post high school educations. Is something happening in their science classes to discourage them from considering careers in science?

Summary and Some Speculation

Problems arise in trying to make too much of the present data on the attitudes of 9-year-olds. There is not enough data and it is very general in nature. There were too few chances to compare responses of the 9-year-olds to older students because of the difference in the questions asked, and there were some important questions that were not asked as part of this assessment.

Nevertheless, if all the data describing general attitudes toward science, experiences with science, and career interests are pooled, some patterns emerge and opportunities for speculation are provided. Certainly, overall attitudes toward science are not good, and probably are not any better than they were at the time of the Purdue Panel survey. The data on 13- and 17-year-olds, especially, are just as alarming as the Purdue data from more than 20 years ago. There are serious problems surrounding students' feelings about science and their interest in science as a career choice.

It is interesting that the data indicate that black students hold more positive attitudes than white students at age 17, but this is because the attitudes of white students have eroded much more than those of black students between the ages of 9 and 17. In the career-choice data, it is the predominantly white, advantaged-urban students whose attitudes have decayed the most from ages 9 to 17 — the students one would expect to be the most positive and remain so. A different problem is that of girls dropping out along the way, a problem that must be dealt with in a systematic way when it first begins to appear, usually in the elementary school classroom.

Even though attitudes data for 9-year-olds seem reasonably positive, by the end of elementary school a serious downward trend is apparent. This downward trend from ages 9 to 17 is not limited to attitudes about science; similar trends can be found for other subjects as well (Johnson and Johnson, 1976). The data may reflect more a decay of positive feelings about school than about science, and it is likely that the answer to developing and maintaining more positive attitudes toward science is to deal with it in the context of improving the total learning environment of schools rather than dealing only with science instruction.

One of the easiest ways to improve classroom (and school) educational climates is to set up appropriate student-student interactions for learning. A considerable body of research indicates that students perceive school as a competitive enterprise and that competition is the dominant interaction pattern; however, a cooperative interaction pattern is much more effective on a range of learning outcomes (Johnson and Johnson, 1976). It has been found that promoting cooperation helps students become more positive about each other, the teacher and the subject matter; students also make gains in achievement. Science is especially well suited to cooperative learning since it emphasizes problem solving, laboratory investigations and the need for divergent thinking (Johnson, 1976). The cooperative goal structure is especially effective at the upper elementary

and junior high school levels, where positive peer interactions are of paramount importance. It would also be expected that heterogeneous, cooperative interaction between boys and girls in science would benefit both, and could help girls maintain a positive interest in science.

Another effective way to improve attitudes would be to emphasize the more active science programs that students indicated a desire for in the assessment data. More field trips, more emphasis on environmental issues and outdoor activity, and more "hands-on" experimenting would not only develop more positive feelings about science, but would be more consistent with how elementary school-age children learn (Johnson et al., 1974). It is appalling that a majority of elementary school teachers report that they have not seen the NSF-funded curricula, but it is a good sign that several of the newer commercial programs are oriented toward learning using concrete materials. However, the problem does not lie with programs, but more with the acceptance of this kind of science teaching by elementary school teachers and their willingness to develop the strategies for teaching a laboratory "hands-on" program. The paradoxical position of the 9-year-old who says, on the one hand, that he or she enjoys finding out things for himself or herself, and on the other hand, that he or she would rather be told the answer, indicates a possible conflict between what students want and what current instruction requires.

The major factor in elementary school science, again, is the teacher. To affect the way science is taught to 9-year-olds, ways will have to be found to significantly affect teachers so that science as a subject is considered important and teachers feel more positive about teaching it. In my own experience as an elementary school teacher in the early 1960s, I was given a chance to go to Boston to work on developing the elementary science study (ESS) program. I had just completed a master's degree in reading, the subject I was told was the only really important one for elementary school. I did not have a high interest in science as I was taught to teach it, and I can still remember the cautious interactions between the teachers and the scientists during that first week in Boston. A team spirit was achieved by the end of summer, however, that saw scientists "at home" in the classroom with children, and teachers comfortable in the laboratory studying bread molds under a microscope. Something in the process made us not only comfortable with teaching science, but also positive advocates of teaching science in the ESS manner. Jim Werntz of the MINNEMAST Project has often remarked that the secret of successful implementation of a curriculum project is to have vast numbers of teachers involved in its development. I would not suggest another round of curriculum development as an answer, but some significant curriculum experience is necessary for elementary school teachers to become positive about science and advocates of teaching it. Perhaps something like the National Science Foundation Institutes or a similar kind of in-depth inservice program is an answer.

Whatever the answers, there is reason for concern about the attitudes of students toward science at age 9 and as they get older. Until some effective interventions are made, 9-year-olds will continue to view science as teacher-led discussions (when any science is taught at all), and there is little hope of science becoming a "basic" in the elementary school or a "favorite" of elementary school students.

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SCIENCE AND SOCIETY:
A Review of the National Assessment Data for 13- and 17-Year-Olds With Implications for Policies and Research

Norris Harms
University of Colorado

Rodger Bybee
Carleton College

Robert Yager
University of Iowa

Rodger Bybee is associate professor of Education, Carleton College, Northfield, Minnesota. He has been involved in research on the relationship of societal problems and science education and has taught science at the elementary, secondary and college levels. Norris Harms is director of Project Synthesis

and evaluation specialist of the Bureau of Educational Field Services, School of Education, University of Colorado. A former member of the National Assessment staff, he directed and coordinated development of the items used in the 1976–77 national assessment of science. Robert Yager is director, Science Education Center; coordinator, Science Teacher Education Program; and professor, Science Education, University of Iowa. He is also director of the Division of Research, National Science Teachers Association, and has served on NSF evaluation panels.

Introduction

Few, if any, would question the importance of science and technology in our society. Research into the causes and cures of disease results in longer life and less illness. Technology brings about better living conditions and more efficient work. Yet, many contemporary social problems are blamed, at least in part, on science and technology. Since science and technology can be simultaneously perceived as a social asset *and* a social liability, what are people's current attitudes toward science and technology? And, of concern to science educators, what are the attitudes of today's junior and senior high school students concerning the relationship between science and society?

Before addressing these questions, it is useful to construct a frame of reference. A little over 20 years ago, Russia's successful launching of Sputnik stimulated a flurry of activity in American science education at all levels. That activity was directed largely toward the development of scientists to reestablish American supremacy in space and military-related "hard" technology. To a large extent, that goal was accomplished. The supply of scientists and engineers has increased during the last decade; in fact, in some cases the supply now exceeds demand.

The post-Sputnik changes in elementary and secondary science education were mainly directed toward curriculum development, teacher training and improvement of laboratory facilities. Activities — funded largely by the National Science Foundation (NSF) — were aimed at developing more accurate texts in the traditional disciplines of physical and biological sciences; improving teachers' knowledge of physics, chemistry, earth science and biology; developing better laboratory facilities for teaching in these areas; and encouraging a view of science as a "narrative of enquiry."

Today's science education generally reflects this 20-year history of events. Students in junior and senior high schools usually are offered a selection of text-structured courses that present current scientific theory in a framework of the classically defined disciplines. These courses are often directed toward the more able students and are designed to prepare them for the next round of study in science. For most students, science education consists of minimal exposure in elementary school, a few years of junior high school science, and usually one year of 10th-grade biology. Fewer than 40% enroll in high school chemistry and less than 20% enroll in physics; even fewer take courses with socially relevant themes, such as environmental science or energy topics.

The post-Sputnik development of science education was a response to social forces *outside* of science education, initiated to allow science education to address problems identified by society in general. Today a similar situation exists, although the stimulus is different. In the seventies, America has been faced with a large number of complex, interrelated issues involving science, technology and society, such as population, food, energy/resources and pollution. Many people expect public education and, more specifically, science education to help prepare students to solve these problems. In response, the National Science Foundation has begun to turn its efforts toward defining "scientific literacy" for *general* rather than specialized populations of students.

The emerging goal, therefore, in science education is to ready students for future roles as concerned and responsible citizens, prepared to deal with critical societal issues. To do so, they need the knowledge and attitudes that will lead to personal actions and public policies that result in some resolution of problems. The National Assessment of Educational Progress (NAEP) affective science data shed considerable light on where teenaged students currently stand in relation to this new goal. These data are examined here as they clarify science/society/technology-related goals and as they suggest some curricular implications.

There are at least four aspects of science education goals that can be illuminated by the NAEP data. First, it is important for people to be aware of science-related societal problems. Second, it is vitally important for people to realize that small decisions, made by individuals in their everyday lives, can cluster into larger societal decisions that may either perpetuate or alleviate social problems. Third, public awareness of the relationship between science and technology and societal problems is essential. Finally, if social institutions are to help ameliorate societal problems, there must be appropriate support for those institutions. Our purpose, then, is to discuss the nature of science education as it relates to public awareness of science-related societal problems; individuals' awareness of how their actions affect such problems; clarification of the nature of science; the pursuit of answers to societally relevant questions; and support for the scientific enterprise.

Knowledge About Societal Problems

Attitudes must be considered in light of the knowledge base from which they spring. If attitudes are to lead to rational and productive behavior, they must be *informed* attitudes, based on a real understanding of the problems at hand.

Several National Assessment cognitive items assess students' knowledge about persistent science-related societal problems. Generally, performance on these items was disappointing. Regarding environmental concerns, only about one-third of the students (29% of the 13-year-olds and 37% of the 17-year-olds) knew that automobiles are the major source of air pollution in most cities; only 30% of the 13-year-olds and 50% of the 17-year-olds knew that nuclear reactor wastes could pollute longer than auto exhaust; fewer than one-third knew that sulfur emissions from smokestacks result in "acid rain"; and only 16% of the 13-year-olds knew that many people in poor countries would starve if insecticides were not used.

Performance was equally disappointing regarding the energy problem — only 23% and 36% of the 13- and 17-year-olds, respectively, knew that the long-term fossil fuel problem is the limitation of supply; only 33% and 46% knew that most electricity comes from coal, gas and oil; and fewer than half of the teenagers knew that plastics and synthetic fibers are made from oil or knew that these synthetics, as well as gasoline, could be made from coal if necessary.

Results were mixed regarding food supply and population problems. However, there was a substantial lack of knowledge about basic facts related to food supply. In addition to the insecticide item discussed above, only 14% of the 13-year-olds and 22% of the 17-year-olds identified a population growth-rate curve that depicted the rapid rate of population increase now existing. Only 36% (age 13) and 38% (age 17) knew that expensive fertilizers are needed to sustain the "green revolution," and only 21% of the younger teenagers and 32% of the older group realized that more people can be supported by eating grain directly than by eating the animals that eat the grain.

In light of students' performance on these and other NAEP cognitive science items, it appears that students are learning considerably more "traditional" science

content than that relating to science/society/technology. The curricular implications of this knowledge gap are discussed later in this section.

The Individual and Societal Problems

In addition to understanding science-related problems, people need to be aware of the implications of their own behavior and be willing to contribute personally to solutions of such problems. The National Assessment report shows that generally high percentages of people thought they "probably could" or "definitely could" contribute to solutions in the well-publicized problem areas of energy shortages and pollution. However, percentages were considerably lower for less well-publicized areas, such as disease control and conservation of natural resources. Even in the areas of pollution and energy, no more than 40% of the teenagers felt that their personal actions "definitely" could help solve problems. Percentages feeling they "definitely" could help in other problem areas were between 10 and 20%.

As noted in the NAEP report, it appears that there is more willingness to help solve problems than there is actual help in terms of self-reported behaviors. This disparity, combined with the relatively low performance on the cognitive items discussed earlier, leads to the conclusion that positive attitudes about willingness to help in well-known "popular" problem areas are largely not internalized, and that these attitudes might not lead to future patterns of behavior that will be helpful in solving societal problems. In the less popularized areas, there appears to be little awareness on the part of teenagers that their actions can have an impact one way or another.

Science and Societal Problems

For a society to make rational decisions about scientific and technological endeavors, the members of that society need to be aware of the relationship between science/technology and the society itself. This awareness should lead to a realistic assessment of the potential and limitations of science and technology for resolving (or creating) problems and to citizen-level support for promising scientific and technological developments. In the National Assessment data, we see pertinent evidence concerning: (1) awareness of the methods, assumptions and values of science; and (2) confidence in science and technology to find solutions for societal problems.

Awareness of the Methods, Assumptions and Values of Science

The sophistication of students' awareness of the nature of scientific endeavors was pleasantly surprising. As reported in the main body of the NAEP report, students had a good grasp of the empirical nature of science. On the items assessed, students seemed weak in only two areas: understanding the dynamic, self-correcting nature of science and knowing the utility of scientific theory for making predictions. In view of the tendency of textbooks to present science as a "body of facts empirically determined," it is not surprising to find that students did not know that "facts" can be subject to change.

Confidence in Science

Students seemed to have largely positive feelings about science. They generally thought science to be moving at the right speed, doing more good than harm, and causing little fear or anxiety.

Confidence in the ability of science to solve particular problems was mixed, however. Most students felt science could help "very much" in solving energy problems and in finding cures for diseases. But fewer than half felt scientific endeavors could do very much for the population-related areas of preventing worldwide starvation, reducing overpopulation or conserving natural

resources. Since there were only nine items measuring confidence in science to solve specific problems, it was difficult to discover detailed patterns in the responses. However, confidence in science is closely related to support for science, and the larger numbers of items in that portion of the assessment permit a more detailed analysis in the following section. It is reasonable to assume that findings concerning support for science, discussed in the next section, are probably also true for confidence in science.

Another aspect of confidence in science is related to societal control of scientific endeavors. Again, most people at all ages felt that the current level of control is appropriate. Ten percent felt controls should be decreased, and slightly more than one-fourth felt controls should be increased. It is interesting to note that about one-fifth of the population at all levels did not respond. Considering the magnitude of science-related problems and the widespread public reporting of them, general confidence in science as expressed in feelings about current societal controls is considerable.

Support for Scientific Endeavors

Students were asked 35 questions about whether or not certain types of scientific study should be financially supported; 14 additional items asked whether or not scientists should be allowed to pursue various controversial research topics. These 49 items permitted a comparison of support for different classes of scientific research. Overwhelming support (over 90% positive) was found for scientific endeavors in the much publicized application areas of research on cancer cures, solar energy and air pollution. Feelings were more negative than positive toward certain other areas of socially relevant research, such as "how people behave in . . . crowded cities," and feelings were very negative regarding controversial research on human genetic engineering.

There was a clear distinction in support for basic versus applied research. Attitudes toward applied research were much more positive than attitudes toward basic research. There were several pairs of items in which an obvious link existed between relatively basic research and research with a fairly evident application. Four of these item pairs and their results follow. The more basic research topic in each pair is presented first.

Data on Basic/Applied Item Pairs

Should scientists be given money to study . . .

	Percent Responding "Definitely Yes"	
	Age 13	Age 17
How continents move around	23%	22%
How to prevent earthquakes	75	78
Small parts of the atom	32	31
Ways to solve energy problems	69	86
New ways to build smokestacks	6	14
Methods of reducing air pollution	78	88
Habits of fish in the ocean	15	21
Ways to produce more food	64	82

The results for these item pairs indicate that there is much more support for research that produces specific, obvious outcomes than for research in which the outcomes, although equally useful, are not so self-evident. A comparison of data for 13- and 17-year-olds on the applied research items reveals increasing levels of support among older students, perhaps reflecting students' growing social awareness during the teenage years. In contrast, attitudes on the more basic research topics do *not* become much more positive between ages 13 and 17. These facts, combined with the large difference between attitudes supportive of basic research versus applied research, lead to the conclusion that students' science education does very little to show them the value of basic research or to demonstrate the connection between research and real world problems. This evidence also suggests that there is greater student awareness of the role of science and technology in developing "technological fixes" or cures for problems than awareness that science discovers basic facts, laws and theories that eventually become useful in a preventive, rather than in a curative, mode.

Implications for Curricula and Research

The patterns of results discussed above have important implications for science curricula. These patterns are convincing evidence that there is a real need to reexamine the role of science education in light of the need for a scientifically literate public.

Considerable evidence suggests that students know very little about the basic nature and causes of important, science-related societal problems; they also did not seem to understand the relationship between relatively basic research and possible solutions to those problems. There is evidence that science is viewed as a "fix it" rather than a "produce knowledge that will prevent it" enterprise. Evidence outside the NAEP data also supports this view of science. For example, a popular but naive belief seems to be that a "Manhattan" or "Apollo" kind of project could help solve problems such as cancer.

Some changes or modifications in science curricula seem indicated. First, there is the obvious need for education about the basic nature of such problems as energy, pollution, population, food supply, disease, resource conservation and human behavior. Citizens need to be aware of causes and contributing factors to such problems so they can evaluate proposed solutions. It is important to understand that this is *not* an argument for education that says, for example, "Pollution is bad," but rather for education that says, "Here are some particular causes of pollution, and here are some specific ways in which individuals and society at large might attack them." Chemistry and physical science texts, for example, could discuss the effects of acids in the atmosphere on both the living and the nonliving world, the chemical origins of those acids (e.g., sulfur in coal), and scientifically defensible modes of reducing the attendant problems.

Second, there is a need to increase understanding of the role of science, especially basic science, in leading to new knowledge that can improve the quality of human life. Examples of the ways in which basic research changes the body of knowledge and the effects of those changes on the ability to solve problems should be included in the curriculum. In addition, a clear distinction should be made between basic and applied science, i.e., technology. Otherwise, citizens may never know that there is any such thing as basic science. In fact, there cannot be a future technology without the continued progress of science, since any technological advances (e.g., in electronics, space travel or solar heating) without prior advances in knowledge of basic science will, of necessity, be limited.

Finally, students need to learn about science-related careers that can be instrumental in helping to solve societal problems. Although the data reveal generally

positive views toward careers as scientists, the assessment did not study in detail attitudes toward other science-related careers. Our inspection of science textbooks reveals little mention of science-related careers other than those as scientists per se. An appropriate science curriculum should now include information on scientific careers at all levels, thus providing students a career awareness in several broad areas of science and technology.

National Assessment data indicate that in many cases students are aware of what they can or should do about science-related problems, but that they do not necessarily act on this awareness. Visible models of desirable new behaviors are one way of encouraging changes in behavior. Science teachers can be important role models for individual action regarding societal problems. We believe this can be done within science classrooms and without the implications of a "radical" or counterculture stance. For example, such things as paper, electricity and water could be consciously conserved in science classrooms.

National Assessment findings regarding science and society have many potential implications for policy decisions and for research. The data provide a knowledge base that can affect curriculum planning, teaching approaches and school facilities. The data also suggest areas for further research. Information on cause and effect in science achievement and science attitudes is needed. Information on perceptions of science held in particular locales and on the relationship between community conditions and science knowledge and attitudes would be useful. Individual student interviews might provide valuable supplemental data. A study of the types of science teaching characterizing successful science programs of today is also an important need.

Research on students' current information about societal issues and science should be conducted, since it is clear that this information is *not* contained in most science curricula presently available. It would be useful to know whether students obtain information in the home or from the media, how different age groups would rank various societal problems and how, if pressed, students would justify their attitudes or positions.

The NAEP data are rich in information and new perspectives on students' understanding of science and science-related societal problems. We now have some information on which to act, to set policies and to change science programs. We have also identified some areas of needed research. The task is now before us. Science education must come closer to meeting the needs of *both* our students and our society.

An Analysis of Minority Attitudes Toward Science From the 1976–77 National Assessment of Science Results

Jane Butler Kahle
Purdue University

Jane Butler Kahle is associate professor, Departments of Biological Sciences and Education, and chairperson, Graduate Studies, Department of Education, Purdue University. She has taught biology at the secondary level and is a recipient of the Delta Kappa Gamma Fellowship for Research as well as a Senior Fullbright-Hays Lectureship.

Introduction

An analysis of minorities' attitudes toward science described by the National Assessment of Educational Progress (NAEP) science assessment of 1976–77 reveals many contradictions and anomalies. This section examines factors affecting minorities to determine possible reasons for their attitudes and potential relationships between attitudes and achievement.

In 1976–77, NAEP collected data on students' (ages 9, 13 and 17) and young adults' (ages 26–35) attitudes toward science as well as on their achievement on cognitive science questions. Questions about science attitudes were grouped under three general topics ranging from personal experiences with and attitudes toward science to attitudes about science and society to awareness of the philosophy and methodology of science (Table 5-1).

TABLE 5-1. Topics and Subtopics Used for Grouping Items Assessing Attitudes Toward Science and Number of Items in Each Topic and Subtopic

	Number of Items Composing Each Topic and Subtopic		
	Age 9	Age 13	Age 17
Personal experience with science	20	24	24
Attitudes toward science education	6	8	8
Vocational and educational intentions	1	4	4
Experience with science-related activities	12	5	5
Personal use of the tools and attributes of science	1	7	7
Science and society	3	10	10
Confidence in science	0	2	2
Support for research	0	2	2
Controversial issues	0	2	2
Personal involvement with science-related societal problems	3	4	4
Awareness of the philosophy and methodology of science	0	3	3

From the Released Exercise Set, Third Assessment of Science, *1978.*

Factors in Interpretation

There are a number of factors in the assessment situation that can confound any interpretation of minorities' responses. Following are some of the major questions that must be considered: Is there consistency between responses to questions on similar topics? Is the language of the questions appropriate? Is the sample representative of the minority population? Is there bias in the minority data?

Consistency of Responses to Similar Types of Questions

One should not evaluate the science attitudes results without also considering

results on achievement items. In particular, one section of the achievement survey, or cognitive assessment, entitled "Science and Society" concerned issues similar to many of those included in the science and society section of the attitudinal survey. Table 5-2 presents topics and subtopics included under the science and society section of the cognitive assessment and the number of questions in each topic for each age level.

TABLE 5-2. Topics and Subtopics Used in the Science-and-Society Area of the Cognitive Science Assessment and Number of Items Composing Each Topic

	Number of Items		
	Age 9	Age 13	Age 17
Persistent societal problems	12	49	57
Health and safety			
Environment			
Growth			
Resource management			
Science and self	14	23	25
Everyday use of science			
Personal health, nutrition and safety			
Applied science/technology	1	14	20
Applications in biological science			
Applications in physical science			
Applications in earth science			
Changes in science/technology			

From Science Achievement in the Schools, *1978.*

The major difference between questions on similar topics in the attitudinal and cognitive assessments was one of phrasing, as seen in the examples in Table 5-3. In general, fewer blacks than whites answered cognitive questions correctly. Blacks were also somewhat less likely than whites to feel that either their actions or scientific endeavors could make a difference in solving various science-related societal problems; however, differences between blacks and whites on attitudinal questions were generally smaller than for cognitive exercises.

TABLE 5-3. Comparison of Cognitive and Attitudinal Items About Pollution

Cognitive	What is the major cause of air pollution?
Attitudinal	Can you help solve pollution?
Attitudinal	Can science help reduce air and water pollution?

From the Released Exercise Set, Third Assessment of Science, *1978.*

Verbal Abilities and Testing Prodedures

Verbal ability also may affect the accuracy of responses. The discrepancies in reading levels and in test-taking techniques between minority and majority children are well documented. Since the majority of items in the science assessment were assessed in a group-administered, paper-and-pencil format, some answers may reflect reading or testing problems rather than being true indicators of attitudes, experiences or skills. For example, when asked if they had ever worked/experimented with sunshine, 4.5% fewer black 13-year-olds and 13.5% fewer black 17-year-olds than the national average answered "yes." However, in responding to an identical question about solar energy, 3.5% more black 13-year-olds and 3.7% more black 17-year-olds than the national average said "yes." Obviously, the validity of these responses must be questioned, especially since numerous items indicated that blacks generally report fewer actual experiences with science investigations and scientific instruments than other students (*Affective Data — Exercise-Level Percentages and Standard Errors*, 1978).

Undifferentiated Minority Groups

For the attitudinal items, data for only the racial categories "white," "black" and "other" were available. It is unfortunate that sample sizes for Hispanos, American Indians, Orientals and other racial/ethnic groups were too small to allow for comparisons with blacks and whites.

Survey Bias

Perhaps the major interpretive concern is the possibility of bias because of nonresponse, which can result in an underrepresentation of minority respondents. Three types of nonresponse can be distinguished.

1. *School nonparticipation.* In most national surveys, minority populations are underrepresented because many inner-city schools refuse to cooperate with testing programs (Coleman et al., 1966; Jencks et al., 1972; Mosteller and Moynihan, 1972).

   In the 1976—77 NAEP assessment, just over 90% of the sample schools participated and no big-city school *districts* refused. The number of inner-city school refusals presently is not available. Nonparticipating schools were replaced by similar schools when possible.

2. *Student participation.* Many schools have average daily absentee rates of 50—70%, particularly in inner-city areas (Eash, 1970; Kahle et al., 1974; Stake and Easley, 1978; Watson, 1978). National Assessment attempts to counter absenteeism problems by oversampling students in schools with high absentee rates and by scheduling make-up sessions when participation rates are low. Using these procedures, participation rates for 9-, 13- and 17-year-olds in 1976—77 were 89%, 86% and 73%, respectively. Special follow-up procedures for 17-year-olds brought their participation rate up to 84%, nearly the same as for the younger ages.

   Participation rates for minorities and inner-city students cannot be directly estimated for the 1976—77 assessment. However, a special study of 17-year-old nonrespondents conducted during the 1972—73 science and mathematics assessment estimated participation rates of whites, blacks and disadvantaged-urban students to be 76%, 66% and 68%, respectively (Rogers et al., 1975), and it is assumed that those rates have not changed substantially. (Further details on the study, including performance and bias estimates, can be found in Rogers et al., 1977.)

3. *Exercise omits.* Omits, or failures to answer items, are a constant problem in

testing. It is particularly serious among blacks, notably in the South (Walberg and Rasher, 1977). National Assessment attempts to minimize omits by arranging exercises for maximum clarity (for example, printing only one item on each page, having students mark answers in the test booklet rather than on a separate sheet and providing a paced audio-tape to minimize reading difficulties), by assuring students that their scores will not be reported and by encouraging students to mark the "I don't know" option if they do not know an answer.

On cognitive science items used to measure changes in achievement between 1972–73 and 1976–77, the average percentage of omits was about 1% for all students and about 2% for black students. On those same exercises, the average percentage of "I don't know" responses ranged from about 9% to 11% for all students across the three age groups and 1–2% higher for black students (*Three Assessments of Science, 1969–77: Technical Summary*, 1979, pp. 67–70). Unpublished figures for all cognitive items in the 1976–77 assessment are almost identical to these figures.

On science attitudinal exercises, the percentage of omits was rarely as high as 1% for all students, and the percentage for blacks tended to range up to 1% higher than that for all students.

Definition of Terms

National Assessment defines a number of population groups that can be considered "disadvantaged," and that typically performed below national levels on cognitive science items. These include blacks, those living in disadvantaged-urban areas and those living in big cities. These groups have a substantial overlap in membership. If we consider the racial composition of large urban areas, about one-half the population of disadvantaged-urban areas and about one-third the population of big cities are black. Most (80%) of the disadvantaged-urban areas are located within the boundaries of big cities (cities with populations over 200,000). The remaining 20% are located in the urban fringes outside the boundaries of big cities. If we consider the distribution of the black population in various sizes and types of communities, we find that about half the nation's black population lives within the boundaries of big cities; about one-third of blacks lives in disadvantaged-urban areas.

Analyses of minorities' attitudes in this section will be based upon responses for the "black" racial group; these will be cross-referenced to the two other categories, "disadvantaged-urban" and "big-city."

For the purposes of this section, *attitude* will be defined as a " . . . mental and neural state of readiness, organized through experience, exciting a directive or dynamic influence upon the individual's response to all objects and situations to which it is related" (McCloskey, 1976, p. 24). Thus, the subsequent discussion uses a broad definition of attitude as a state of readiness and a narrow description of minority.

Factors Affecting Science Attitudes of Minorities

A major anomaly was found in the responses of minorities to the cognitive and attitudinal sections of the NAEP science assessment.

> Groups which are traditionally considered as disadvantaged and that usually do less well than other groups on cognitive items – blacks, those living in disadvantaged-urban areas, those living in the Southeast – showed more favorable attitudes toward science classes and science as a career than other groups traditionally viewed as more advantaged (Chapter 4 of this report.)

These groups were typically below the nation on science-and-society attitudinal items measuring support for research and personal involvement in solving science-related societal problems. However, these differences from the nation generally were slight. (See Chapter 4.) Yet, these same groups consistently performed lower than the national average on all cognitive items, including the ones in the science and society cognitive area (*Affective Data — Standard Errors of the Mean*, 1978). As Table 5-4 shows, blacks, Hispanos, students from disadvantaged-urban areas and students from big cities were significantly below the national means on the various cognitive items.

TABLE 5-4. Selected Group Differences From the Nation for All Cognitive Items and for Science-and-Society Cognitive Items, Ages 9, 13 and 17

All Cognitive Items

Age	Number of Items	Difference From the Nation† White	Black	Hispanic	Disadvantaged-Urban	Big City
9	209	2.5*	-12.9*	- 8.5*	-11.7*	-4.7*
13	284	2.9*	-11.7*	-10.3*	-11.1*	-2.2*
17	313	2.6*	-15.7*	-10.8*	-12.3*	-5.8*
Science and Society: Persistent Societal Problems						
9	12	2.2*	-10.9*	-10.6*	-11.9*	-4.4*
13	48	2.7*	-10.6*	-10.2*	-10.2*	-2.8*
17	56	2.9*	-17.2*	-12.3*	-13.7*	-7.3*
Science and Self						
9	14	2.6*	-13.1*	- 9.5*	-12.7*	-3.9*
13	22	3.2*	-12.1*	-11.8*	-10.3*	-2.7*
17	25	2.3*	-13.4*	-10.5*	-12.8*	-4.9*
Applied Science and Technology						
9††						
13	15	2.8*	-10.9*	- 7.3*	-10.9*	-1.1
17	21	2.7*	-15.9*	-11.0*	-10.4*	-6.6*

**Indicates mean percentages significantly different from the nation at the .05 level.*
†Positive numbers indicate that a group performed above the national average by the number of percentage points shown; negative numbers indicate performance below the national average.
††There were not enough exercises administered to 9-year-olds to allow summary percentages.

Simpson (1977, p. 42) stresses the importance of the interrelationship between attitudes and achievement:

> . . . [A]s students move through various grade levels, feelings toward themselves play an increasingly important role in how they do academically. These attitudes form gradually, [once formed] tend to be stable. Success in junior high school science, and to a greater extent high school science, is thus a product of

> a set of complex, accumulative feelings derived from earlier successes and failures.
>
> However, data from the NAEP assessment appear to contradict this assertion.

As one addresses the inconsistencies between the attitudinal and achievement responses of blacks and disadvantaged-urban youngsters, one must look beyond the child and parent, beyond the classroom and school, to the community and culture for answers. This section will discuss societal, educational and personal factors that may affect the attitudes expressed by blacks and disadvantaged-urban students.

Societal Factors

Poverty. First, an overwhelming ethic of poverty influences the minority child. The minority populations of our inner cities and of our most rural areas are categorized as "deprived" because many families in these areas live on annual incomes of less than $6,000.[1] McCloskey (1976, p. 4) has said that "poverty is an overriding condition of disadvantaged children." This poverty, he maintains, constricts children's experiences and imposes burdens of abstinence, negation and humiliation upon them.

Recent estimates are that between 70 and 80% of the black population of large Northern cities are lower class, regardless of the criterion used to establish class; that is, whether it is defined in terms of wealth, education, quality of life, occupation or aspiration (McCloskey, 1976, p. 7). Unfortunately, McCloskey's quotation from Newton (1964) is often all too true today.

> . . . [A] child living in disadvantaged circumstances . . . is a member of a submerged but visible cultural minority. His limited horizons in his limited life function as a depressant to his motivation, aspirations and [thus to his achievement].
>
> He frequently has contradictory attitudes toward self and others with low self-concept and the resultant exaggerated positive and negative attitudes toward others.
>
> The sociocultural standards of his family [and neighborhood] are noncomplementary to social stability and academic achievement — hypermobility, family instability, distorted model relationships, housing inadequacy, economic insufficiency, as well as hyper- and hypostimulation.
>
> He is usually a member of a family in which there are less than two full generations of literacy.
>
> He frequently performs several years below grade expectancy on verbal tests, but often demonstrates normal learning potential on nonverbal tests.
>
> His style and modes of perceptual habituation do not complement the emphases that are important to traditional academic success.
>
> He has marked weakness in utilizing abstract cognitive processes [due to vocabulary difficulties] and favors concrete stimulus-bound learning situations.
>
> These conditions, then, permeate the lives of many minority students and affect their attitudes toward society, school and science.

The large migration by minority families to large cities in the last two decades has also contributed to their impoverishment. The newcomers often are limited by their lack of integration into social or civic organizations.

[1] McCloskey (1976) estimates that half of our population classified as deprived reside in large cities and half live in remote, rural areas.

As Tables 5-5 and 5-6 show, black students simply do not have as many experiences as white students with science and science activities to form a background for their attitudes. Many of these experiences, often available through participation in Girl or Boy Scouts, Camp Fire programs, YW or YMCA, or other groups either are not, or are not felt to be, accessible by minority or inner-city youth. Thus, responses to science attitudinal questions may reflect not their informed attitudes but opinions that they feel they *should* have.

These circumstances — financial and social poverty — affect the lives, learning and attitudes of minority populations. As Green (1978, p. 1988) states:

> [U]pward mobility is still an unknown phenomenon to a large number of minority people. While the proportion of blacks in the middle-income groups is on the increase, so is the proportion of those below the poverty line. Unemployment for blacks in 1977 was at an all-time high — 60% among black teenagers. The number of blacks unemployed rose between 1975 and 1977, while that among whites dropped by a million. Today, the estimated 7 to 10 million people who are in a state of virtually permanent unemployment are predominantly members of minority groups.

One pervasive factor, then, that influences the attitudes expressed by minorities toward science is the circumstance of poverty. In spite of federal programs, little progress has been made in alleviating or ameliorating this condition.

Life style. Minority children are limited by having fewer outside experiences than majority children, according to all surveys and analyses of their life styles. Deutsch (1963) states that 65% of the ghetto children he studied had never traveled beyond a 25-block radius of their homes. Teachers also note the effects of a constrictive environment, indicating that the lack of reading material in the home deleteriously affects reading ability and habits. Furthermore, Deutsch (1964) states that while 50% of the children he studied could not recall seeing a pen or pencil in their homes, 60% of them reported having television. In addition, Beman (1972) reported the results from a cross-cultural survey of parents of low socioeconomic status in Houston, Texas (Table 5-7). The lack of educational opportunities in the lives of minority children provides fewer experiences for them to use in formulating attitudes about disciplines such as science.

Education Factors

The educational influences affecting science attitudes of minorities are many. The following major ones will be discussed: segregation by school and by classroom, fewer educational and occupational opportunities, lower teacher expectations, classroom practices and lack of extracurricular, science-related activities.

Segregation by school. A quarter of a century has passed since the U.S. Supreme Court declared unconstitutional "separate, but equal" schools. This decision proclaimed that segregated schools are illegal, yet Clark (1978) maintains that the percentage of black children attending segregated schools in Northern cities has increased since 1954. Furthermore, the U.S. Commission on Civil Rights reports that the proportion of black pupils in predominantly white, Northern schools increased less than 1% between 1968 and 1972 (Green, 1978).

National Assessment data (*Science Achievement in the Schools*, 1978, p. 42) indicate that in the Southeast approximately 30% of the black 9-year-olds, 39% of the black 13-year-olds and 47% of the black 17-year-olds attend schools that are 60—100% white. Between 20% and 30% of the black students at these ages attend 60—100% white schools in the Northeastern, Central and Western regions. Despite this evidence of partial integration of the nation's schools, the

TABLE 5-5. National Percentages Responding Affirmatively and Selected Group Differences From the Nation Regarding Actual Science Experiences Reported, Ages 9, 13 and 17

	National Percentage			Difference From the Nation					
				Whites			Blacks		
Had students actually seen . . .	Age 9	Age 13	Age 17	Age 9	Age 13	Age 17	Age 9	Age 13	Age 17
A sprouting seed?	57.0	69.2	81.3	3.7*	3.8*	3.4*	-11.6*	-14.3*	-15.8*
An egg hatching?	43.7	53.5	56.1	-1.2	2.0*	2.2*	3.8	- 9.4*	-12.6*
An animal being born?	48.9	60.3	62.4	-1.4*	0.7	0.7	8.6*	- 3.6	- 5.7
A fish eating?	80.8	90.7	92.7	1.7*	0.8*	0.2	- 7.2*	- 3.3*	- 1.6
Ants or bees working?	72.9	87.6	93.2	3.8*	2.4*	1.0*	-16.7*	- 8.8*	- 4.4*
Birds caring for young?	63.4	77.4	81.1	0.8	0.4	0.1	- 2.7	0.0	0.6
The North Star?	42.6	58.8	73.5	1.7*	5.9*	5.4*	- 6.3*	-23.9*	-29.5*
The moon through a telescope?	34.5	48.4	56.8	0.1	3.8*	3.5*	0.1	-16.2*	-18.4*
An animal skeleton?	61.9	83.8	87.7	1.7*	2.2*	1.8*	- 8.9*	- 8.6*	-10.2*
A fossil?	53.2	84.3	90.0	4.1*	5.0*	3.1*	-18.3*	-19.3*	-15.0*

**Indicates difference is significant at the .05 level.*

From the Released Exercise Set, Third Assessment of Science, *1978, and an unpublished printout on affective data, 1979.*

TABLE 5-6. National Percentages Responding Affirmatively and Selected Group Differences From the Nation Regarding Actual Science Field Trips Reported, Ages 9, 13 and 17

	National Percentage			Difference From the Nation					
				Whites			Blacks		
Have you ever actually visited . . .	Age 9	Age 13	Age 17	Age 9	Age 13	Age 17	Age 9	Age 13	Age 17
A planetarium?	32.3	55.3	66.7	0.0	2.2*	2.5*	-1.6	-5.5	-15.9*
A zoo?	87.4	94.3	96.6	0.5	0.9	0.2	-7.9*	-2.9	- 2.4
A museum?	70.7	93.3	95.5	0.9	1.5*	0.5*	-8.5*	-8.2*	- 4.6*

**Indicates difference is significant at the .05 level.*

From the Released Exercise Set, Third Assessment of Science, *1978, and an unpublished printout on affective data, 1979.*

TABLE 5-7. Parent Interview: Data for Local Visits

	Mexican-American	European-American	Negro-American
This city has many attractive places to go (listed on survey). How many have you taken your child to?			
Exact number of places:			
3	13	5	13
6	5	12	6
Do your children know where the public library is?			
No	15	1	17
Yes	42	57	42
Do they go there?			
No	21	3	30
Yes, on their own	26	54	17
Yes, with parents	10	1	11

effects of continued segregation on minorities' attitudes and achievement remain today. As Stake and Easley (1978, 14:11, 12) suggest, the problem is multifaceted:

> It is not the fiscal provisions that concern us here but the more fundamental differences in opportunity to learn, involving the competence of the teacher, the quality of the learning materials, the learning place(s), the peer group of students engaged in learning.
>
> It appeared to us that the schools actually do quite well in providing a parity of spaces and books suitable to the task. The teachers fell short of the ideal, especially in the poorer schools, but even there were often the strongest of the ingredients. What became obvious to us in these studies was that many of the poorer schools cannot provide a learner with a classroom of fellow students who can and will use a greater portion of the lesson period for learning.

In areas where desegregation has taken place, questions concerning its effects on the attitudes of minority children remain. Bradley and Bradley's (1977) extensive review of black students in desegregated schools presents conflicting evidence concerning black achievement and adjustment in desegregated schools. They suggest that one of the few positive outcomes of desegregation may be what has been termed the "lateral transmission of values" (p. 403) from white to black schoolmates. If the values transferred include self-respect and self-confidence, they could, indeed, affect blacks' achievement and attitudes, but the results are not definitive.

An examination of some of the attitudinal responses of black students indicates generally positive immediate attitudes, but more nebulous ones about the scope and use of science. For example, more blacks at age 17 found science seldom or never boring (27% of blacks compared with 18% of whites), found it always or often fun (31% of blacks compared with 26% of whites) and always or often liked to go to science classes (48% of

blacks compared with 35% of whites) (*Affective Data — Exercise-Level Percentages and Standard Errors*, 1978). But these same black students had fewer science experiences, found science less useful out of school and were less aware of scientific methods and of how scientists work (*Affective Data — Standard Errors of the Mean*, 1978). Furthermore, they were less confident in the ability of science to solve current or future problems. Overall, black students appear to like science, but many do not understand its methodology, technology or potential.

Segregation by classroom. The effects of segregation on the attitudes and achievements of minorities do not stop at the school level; thousands of classrooms are segregated, either by formal or informal procedures. These practices result in fewer opportunities open to minority students, and they are rampant in the sciences, the "elitist" courses of the public schools (Stake and Easley, 1978).

Formal methods of segregating classrooms usually involve either "tracking" or "grouping" of students by ability, by occupational intention or by prerequisite. Tracking denotes the long-term assignment of students into different groups taught with different long-term objectives and with little provision for, or expectation of, reassignment. This practice was declared unconstitutional in 1967, yet three recent national surveys of science education report instances of it (Stake and Easley, 1978; Helgeson et al., 1978; Weiss, 1978).

Although grouping denotes more flexibility and temporary assignments, in practice, few reassignments occur (Stake and Easley, 1978). Furthermore, grouping often results in segregated classrooms in desegregated schools. Consider the following description of two types of math classes in a California school (Stake and Easley, 1978, 14:17, 18).

Number of Students in Different Classes

	White	Oriental	Black	Hispanic
Advanced math	15	3	0	0
General math	10	0	8	8

Stake and Easley also report that over 60% of the students in the lowest level of science classes in a Texas school were black males, assigned first because of a reading problem, second because of a math problem, third because of a discipline problem, and last because of a science problem. This second type of segregation, within the classroom, affects attitudes and achievement in much the same way school segregation has. Minority students often are isolated, and there are few opportunities for even the "lateral transmission of values" to occur.

Classrooms are also informally segregated by the requirement of prerequisite classes. Many minorities do not take science courses because they have not been counseled into the academic "tracks" or into the prerequisite mathematics courses (Shorter, 1979). The doors are shut before they can be opened. Consider Table 5-8, adapted from Ignatz (1975).

TABLE 5-8. Percentage by Race Enrolled in Science Courses in 44 Public High Schools in Northern Florida†

Course	Percentage of Blacks	Percentage of Whites
Biology II	23	77
Chemistry I	9	91
Chemistry II	6	94
Physics I	7	93
Other	29	71

†Total enrollment: 28,121 (75.2% white and 24.8% black).

Although black enrollment in Biology II is similar to their percentage of the total enrollment, blacks are notably underrepresented in the physical science classes listed. This underrepresentation is reflected in two ways in their attitudinal responses. First, more adult blacks than whites stated that science has made no changes in their lives. Conversely, black students appear to place more value than whites on what they, perhaps, have not been able to have due to formal or informal segregation practices. Eighty-two percent of black 17-year-olds, compared with 59% of white 17-year-olds, think that science should be required in school; and 72% of black 17-year-olds, compared with 53% of their white counterparts, think that science education in the long run is worth the expense and effort expended.

Educational and occupational opportunities. The attitudes of minority students also may be affected by fewer educational and occupational opportunities. Although the dearth of educational opportunities has been documented in the sections discussing school and classroom segregation, a few other factors will be enumerated. Walberg and Rasher (1977, p. 704), in their analysis of state-by-state failure rates on the selective service mental ability test, found that "regression analysis shows that high failure rates are significantly associated with low levels of adult education, small population size, and high percentages of black and Spanish-origin residents of the state." Furthermore, they report that higher percentages of children enrolled in public schools[2] and lower pupil/teacher ratios are significantly related to lower failure rates, and that a reduction of one pupil per teacher will lower the failure rate by an estimated 7.4% when other variables are controlled. Their tabulation of pupil/teacher ratios shows high ratios for scattered states in the Far West and for most of the states in the Southeast (p. 706). The low percentage of children enrolled in public schools in urban areas also affects the failure rates in those schools.

In addition, many blacks have fewer educational enrichment opportunities in their homes. There is often a paucity of verbal communication, which may contribute to poor verbal abilities, according to Silberman (1964), and generally their homes are poor places in which to study.

The effect of a lack of educational opportunity is cumulative. For example, in 1974 53.5% of high school seniors from families with incomes of $25,000 or more planned to go to college, while only 12.4% of those from families with incomes less than $5,000 had similar plans (*The Effect of Poverty on Education*, 1976). This lack of educational opportunities directly correlates with the lack of occupational opportunities, and blacks are grossly underrepresented in scientific careers. Consider the following occupational information for blacks, who constitute 10% of the U.S. population (Hale, 1978, p. 205S).

Occupation	Total Number	Number of Blacks	Percentage of Blacks in Occupation
Physicians	325,000	3,500	1
Dentists	110,000	2,700	2
Engineers	40,000	400	1

[2] States with the lowest percentage of public school enrollment, with the exception of the South, have higher percentages of black residents and contain several of the major urban concentrations (Milwaukee/Chicago, Pittsburgh, Boston, New York/Newark) (Walberg and Rasher, 1977, pp. 705–706).

The combined effect of lack of educational and occupational opportunities is reflected in disparate ways in the attitudinal data. First of all, black students expressed positive feelings toward the value of science education. At age 17, the following percentages of positive responses were found:

	Percent Responding 'Yes'	
	Whites	Blacks
Science education would open many job opportunities.	63	77
Science education is worthwhile even if I didn't enter into a science career.	51	70

The second trend, however, does not suggest positive attitudes. A series of questions concerning long-range support for scientific research indicated that 4% fewer black 13- and 17-year-olds and 9% fewer black adults were supportive of research than their white counterparts. An illustration of this lack of support was reported by an upward-bound science teacher. During the first moon landing, he used television, newspaper clippings, and other means to stimulate discussion and study. However, his black, disadvantaged students were simply uninterested (Bybee, 1979). Likewise, a popular magazine described a scene in a Harlem bar during the moon landing in which no one watched the television account of that scientific achievement. Science research simply does not seem to affect the lives of poor, urban minorities.

Teacher attitudes and expectations. Teacher attitudes and expectations influence both the positive self-concepts and the academic achievements of their pupils; these two factors in turn affect students' attitudes. Studies by Adenika and Berry (1976), Dusek (1975), Deutsch (1960), and Davidson and Lang (1960) present evidence that teacher expectations for minority children are lower than they are for whites. For example, black teachers in low-income areas described their black students as fun-loving, happy, cooperative, energetic and ambitious; while white teachers perceived the same students as talkative, lazy, fun-loving, highstrung and frivolous (Gottlieb, 1964). Recent research, however, indicates that more positive teacher attitudes and expectations may be found in younger teachers (Karlins et al., 1969), and the National Assessment attitudinal responses, tabulated in Table 5-9, indicate that, overall, science teachers are perceived positively by their students. This positive student perception may relate to positive teacher expectations, or it may simply mean that science teachers do well at "entertaining" their students.

Classroom practices. The 1976–77 National Assessment survey of attitudes included questions concerning classroom practices and procedures; responses to these questions may help explain the positive attitudes of minorities toward science classes. Answers to questions about instructional practices in science classrooms are tabulated in Table 5-10. An analysis of them shows two patterns. First, it reveals an almost complete lack of flexible or individualized instructional practices in junior and senior high schools. For example, fewer than 10% of the 17-year-old students have helped select the manner of learning, the sequence of topics or the time of testing in their science classes. One national survey (Weiss, 1978) indicates that science teachers are concerned about using student-oriented, individually paced programs and that 29% of them indicate that the lack of appropriate individualized materials ranks first among 18 instructional problems. Individualized science materials have been developed, and many are commercially available; however, on the whole, teachers are unaware of them and do not use them (Weiss, 1978; Stake and Easley, 1978).

The national concern with compensatory education for culturally and economically deprived minorities may have resulted in the

TABLE 5-9. National Percentages Responding Affirmatively and Selected Group Differences for Students Reporting Favorable Perceptions of Science Teachers, Ages 9, 13 and 17

My most recent teacher . . .	National Percentage			Difference From the Nation					
				Whites			Blacks		
	Age 9	Age 13	Age 17	Age 9	Age 13	Age 17	Age 9	Age 13	Age 17
Really likes science.	36.5	75.8	81.0	-4.1*	1.5*	1.0*	18.8*	- 8.2*	- 3.0
Makes science exciting.	70.4	58.1	47.9	0.3	-1.4*	-2.1*	- 0.7	4.9	13.4*
Is enthusiastic.**	---	52.0	57.2	---	2.0*	0.9	---	-11.4*	- 1.8

**Indicates difference is significant at the .05 level.*

***Nine-year-olds did not respond to this question.*

From the Released Exercise Set, Third Assessment of Science, *1978, and an unpublished printout on affective data, 1979.*

TABLE 5-10. National Percentages Responding 'Always' or 'Often' and Selected Group Differences on Items Concerning Instructional Strategies and Classroom Management, Ages 13 and 17

Have you . . .	National Percentage		Difference From the Nation							
			Whites		Blacks		Disadvantaged-Urban		Big City	
	Age 13	Age 17	Age 13	Age 17	Age 13	Age 17	Age 13	Age 17	Age 13	Age 17
Chosen topics/ projects yourself?	17.1	18.8	-1.2*	-0.9	5.6*	7.8*	11.4*	6.8*	0.4	4.6*
Chosen the way you want to learn?	11.1	8.1	-1.7*	-1.6*	7.9*	8.0*	11.3*	9.4*	0.9	2.5
Selected study sequence of topics?	13.5	7.8	-1.8*	-1.6*	8.5*	6.7*	13.8*	6.3*	1.9	6.9*
Decided when to take tests?	16.7	8.4	-1.0	-2.1*	2.5	9.1*	4.3	10.0*	-2.3	3.8*
Gotten to work at your own speed?	44.7	24.0	-1.3	-2.9*	6.4*	18.2*	7.9	17.6*	0.7	8.5*
Followed exact order of textbook?	46.9	39.1	-3.5*	-2.6*	16.3*	13.6*	12.5*	6.9	1.5	4.9

**Indicates difference is significant at the .05 level.*

From the Released Exercise Set, Third Assessment of Science, *1978, and an unpublished printout on affective data, 1979.*

second pattern discernable in Table 5-10; that is, black students, at both ages 13 and 17, have *more involvement* with determining the instructional practices in their science classes than whites. This involvement may indicate more individualized instructional practices. For example, over 18% more black 17-year-olds than the national average have worked at their own speed.[3]

Likewise, between 7 and 9% more black 17-year-olds than the national average have chosen their own topics or projects, have elected the way they want to learn, have selected the sequence of topics in science and have decided when to take tests. All of these responses are indicative of individualized modes of instruction.

Kahle (1975), Kahle et al. (1976a, 1976b), Nordland et al. (1975) and Douglas et al. (1979) have carefully documented both the affective and achievement gains that accrue from utilizing individualized instruction with academically disadvantaged students. The evidence of greater utilization of individualized materials and/or modes of instruction in urban areas is one of the positive trends indicated in the NAEP survey of attitudes. Furthermore, such classroom procedures, which foster positive self-concepts by encouraging achievement, may have positively affected the attitudinal responses of minority, disadvantaged students.

Extracurricular science activities. Questions concerning extracurricular science activities — such as reading science articles, doing science projects and watching science-related TV shows — were included in the attitudinal assessment. As Table 5-11 indicates, responses from blacks, students in disadvantaged-urban areas and those in big cities generally indicated more involvement than the national averages.

The information in Table 5-11 not only contrasts with other research cited, but it also contradicts the pattern indicated in Tables 5-5 and 5-6 concerning outside experiences. An interpretation of these responses must consider the possibility of a positive bias in the minority data as well as the possibility that students may be responding in the way they think they should. The latter possibility cannot be ignored. It may be attributable to isolation and insulation from normal rewards and success patterns. That is, students may answer randomly or what they perceive as appropriately because of passive noninvolvement. In the *Case Studies* reported by Stake and Easley (1978, 13:24) there were innumerable examples of this type of behavior. For example, one student, when chided for not paying attention, responded, "I heard the question; I just don't care." She/he might just as easily have marked a response at random in a national survey of attitudes toward science.

Factors that may be largely described as educational — segregation, educational and occupational opportunities, teachers' attitudes and expectations, classroom practices, and extracurricular science activities — have been discussed in relation to the attitudes toward science evidenced by black students. There are many responses that are difficult to explain in light of the research on the education of minorities in this country. For example, do more black 13-year-olds and 17-year-olds than the national averages really read science books? Have black 17-year-olds really done science projects more often than the national average? If so, why haven't these activities contributed to increased achievement levels or facilitated the entry of more blacks into science-related careers? An analysis of certain personal traits of minority children may help explain some of these remaining inconsistencies.

Personality Factors

The values, attitudes and learning styles of disadvantaged, minority populations are

[3]There is a high degree of similarity between the responses for black, disadvantaged urban, and to a lesser extent, big-city categories in Table 5-10.

TABLE 5-11. Percentages Responding 'Always' or 'Often' Regarding Extracurricular Science Activities, Ages 13 and 17

	National Percentage		Difference From the Nation: Whites		Blacks		Disadvantaged-Urban		Big City	
	Age 13	Age 17	Age 13	Age 17	Age 13	Age 17	Age 13	Age 17	Age 13	Age 17
Read science articles in magazines	46.8	47.7	-1.2	-0.3	4.9	6.0*	4.3	6.9	4.0	1.7
Read science articles in newspapers	41.4	46.7	-0.7	0.5	1.2	3.6	1.1	4.9	1.1	4.4
Watched scientific television shows	57.7	61.7	-0.1	1.4*	- 0.9	-8.2*	1.6	-1.6	-0.2	-2.5
Gone to a science lecture	8.3	7.6	-1.9*	-1.0*	8.9*	3.9*	15.2*	4.1	5.0*	5.6*
Read books on science	44.8	29.0	-4.0*	-2.8*	17.6*	16.6*	19.6*	16.1*	7.0*	7.9*
Talked to friends about science	41.3	36.9	-1.0	-0.4	5.2	1.7	2.4	10.9*	0.9	3.5
Not required, but did science project	68.0	49.0	-0.9	-1.8*	3.7	16.0*	3.6	7.6*	-0.9	4.6
Not required, but did science hobbies	45.5	37.2	-0.1	0.4	- 0.1	-0.1	7.8	3.2	0.1	0.4

**Indicates difference is significant at the .05 level.*

From the Released Exercise Set, Third Assessment of Science, *1978, and an unpublished printout on affective data, 1979.*

affected by their environment and their education. Generally, they differ from majority students in their value systems, in their perceptions of the locus of control and in their styles of learning.

Values. Although the urban poor share many values with society as a whole, the limiting circumstances of their lives lead them to be influenced by a sense of immediacy and to perceive their environmental limitations as fate, or as chance. They often feel that they have little control over their actions or their lives, and superstition may have an overriding influence on their behavior (Rowe, 1978a; Lefcourt and Ladwig, 1965a; and Hunt and Hardt, 1969). They tend to value traits of strength and endurance such as physical aggression and "smartness." Furthermore, they place a higher value on concrete, immediate goals than on abstract, long-range ones (McCloskey, 1976).

Values within a group are fairly permanent, and values of the minority poor are certain to affect their attitudes toward science. In the NAEP survey, the influence of the value system of many blacks may be demonstrated by (1) their positive attitudes toward concrete science activities, (2) their negative attitudes concerning the possibility of science influencing their "real" lives and (3) their questioning attitudes about the ability of scientific research to improve the quality of life.

Another aspect of the effect of values concerns the context in which the questions were posed. In the NAEP attitudinal survey, questions were framed within the value system of society as a whole. Since there are differences in the value orientation of minorities and of majorities in our society, the questions might not have been presented within a value system important to an urban, disadvantaged student: for example, a student could not indicate the influence of superstition or aggression on his/her attitudes toward science. This lack of pertinent reference points may have contributed to random answering by minority students.

Attitudes. Attitudes of various subcultures often are drawn from their value systems. Several authors have noted that antagonism, suspicion and fear of failure may develop in relation to a child's poor self-image that, in turn, may be brought about by a realistic appraisal of his/her relative position in society. As McCloskey (1976, p. 25) notes, "Attitudes evolve as selective responses to perceived realities. They may serve the disadvantaged child as protective mechanisms that he needs to achieve and maintain mental health amidst the tensions, stress, noise and confusion of the environment, from which he has no immediate escape."

The NAEP assessment reveals that minorities do not have negative attitudes toward many aspects of science, perhaps because science is not a reality in the life of a disadvantaged-urban child. For example, there is evidence of fewer experiences with science or regard for science-and-society issues. At age 9, fewer blacks perceive pollution and energy waste as problems; 19% fewer blacks than whites are willing to use less electricity; 17% fewer are willing to walk or to ride bikes in order to conserve energy. These responses may be indicative of an attitude of alienation, or they may simply be the result of fewer material resources.

Locus of control. A large body of research indicates that many of the actions and attitudes of the disadvantaged child may be correlated to an inadequate sense of fate control. That is, the economically deprived, minority child is more likely to view life as a game of craps over which she/he exerts little or no influence (Rowe, 1978b). This attribute, referred to as fate control, is based on Rotter's (1966) explanation of a personality dimension called locus of control. Rotter maintains that the locus of control exists along a continuum from internal (self) to external (other). He states that the concern is not with the variable itself, but rather with whether individuals believe that their own behaviors, skills, and so forth control what happens in their lives or if they maintain that

their circumstances and conditions are based on chance.

Several studies (Lefcourt and Ladwig, 1965a and 1965b; Rowe, 1978a) indicate that low-socioeconomic-level blacks are a highly external-control-oriented group. Beman's (1972) assessment by Piagetian tasks of the cognitive development of whites, blacks and Hispanos supports this theory. She states (1) that the processes of assimilation and accommodation are different ways of handling stimuli and (2) that Negro-Americans are overaccommodating in their approach to problem-solving tasks. She says:

> Expectation of an unpredictable environment results in an attempt to change behavior to fit whatever may come, with little attempt to sort stimuli, using some and rejecting others. Anything may be important. The result is a failure to relate similarities from one situation to another or to impose any order on the environment (p. 74).

These actions describe a person who has little belief in his/her own ability to control his/her life or environment.

Certain questions in the NAEP science attitudinal survey are interesting in light of the concept of fate control. The responses tabulated in Table 5-12 show that black and disadvantaged-urban students at ages 13 and 17 show less belief in logical explanations and less persistence in working with problems.

According to Rowe (1978b), these characteristics are consistent with an orientation toward external control. The effect this orientation can have on attitudes has not been measured, but it seems reasonable to assume that many of the discrepancies in the responses are due to that orientation. For example, if one believes that the teacher, or luck, rather than studying, controls one's learning, one could easily enjoy a class without learning much. This may explain what the results of the 1976–77 national assessment of science show: disadvantaged-urban students and blacks scored less well on cognitive items than the national average, but they demonstrated more favorable attitudes toward science, science classes, science teachers and science careers.

Learning styles. Two distinct styles of learning have been described by Witkin et al. (1962): (1) field-dependent, in which the perception of the field dominates that of its parts, and (2) field-independent, in which items are perceived as distinct from the organized field. This dimension has been explored cross-culturally by Ramirez and Castaneda (1974), by Ramirez and Price-Williams (1974) and by Witkin (1967). Their work indicates that black and Hispanic children are more field-dependent in their orientation. Furthermore, Ramirez and Price-Williams (p. 212) have stated that " . . . cultural values reflected in socialization practices affect development of cognitive style in children." Although the effect of specific cognitive style on attitudes has not been examined, it is known that American education, particularly science education, is generally organized and presented in a field-independent mode. The lower achievement levels of minorities may be in part attributable to an incompatibility between the cognitive style of the teaching and the cognitive style of the learner.

An examination of the personal values, attitudes and learning styles of blacks and disadvantaged-urban residents shows some unresolved areas, for example, the relationship between cognitive style or fate control and attitudes. However, this examination has provided many insights into the disparate responses between some of the attitudinal areas and between attitudinal and cognitive sections of the science assessment.

Summary

In summary, the attitudes of minorities toward science may be gleaned only partly from the 1976–77 assessment. Although

TABLE 5-12. National Percentages Responding 'Always' or 'Often' and Selected Group Differences on Selected Questions Demonstrating Locus of Control Orientation, Ages 13 and 17

	National Percentage		Difference From the Nation							
			Whites		Blacks		Disadvantaged-Urban		Big City	
	Age 13	Age 17	Age 13	Age 17	Age 13	Age 17	Age 13	Age 17	Age 13	Age 17
Do you believe that there are logical explanations for the things you see happen?	59.6	68.1	2.1*	2.6*	-12.2*	-13.3*	-5.4	-11.6*	0.2	-4.1
How often do you keep working on a task even if you run into problems that you didn't expect?	52.3	60.9	1.8*	2.0*	- 9.3*	- 8.3*	0.3	- 9.1*	4.9	2.1

**Indicates difference is significant at the .05 level.*

From the Released Exercise Set, Third Assessment of Science, *1978, and an unpublished printout on affective data, 1979.*

positive attitudes of blacks and disadvantaged-urban students toward science, science classes and science teachers are rewarding and reassuring, the questions have been largely posed within the social and cultural framework of the majority; attitudes of alienation, feelings of antagonism, perceptions of isolation may not have been thoroughly assessed. Furthermore, testing problems such as item wording, sample size and test avoidance have not been completely resolved. For a thorough analysis of minorities' attitudes toward science, the interrelationship between fate control and attitudes and the effect of cognitive style on attitudes need to be studied.

The National Assessment data show that blacks like science and are active in extracurricular science activities. However, they perform fewer science experiments in school, have fewer outside experiences with science and do not relate science to their home and/or family lives; and, they learn less science. We have not presented a definitive explanation of this basic anomaly. However, we hope that the explanations and research presented here help to place minorities' attitudes toward science in a societal, educational and personal context that makes the often discrepant and disparate responses more understandable.

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